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MINERAL RESOURCES OF THE CHARLES SHELDON WILDERNESS STUDY AREA, HUMBOLDT AND WASHOE COUNTIES, NEVADA AND LAKE AND HARNEY COUNTIES, OREGON

By J. B. Cathrall, R. C. Greene, Donald Plouff, D. F. Siems,
G. L. Crenshaw, and E. F. Cooley, U.S. Geological Survey, and
E. T. Tuchek, F. J. Johnson, and M. D. Conyac, U.S. Bureau of Mines

Open-File Report 78-1002

1978

This report is preliminary and has not been
edited or reviewed for conformity with U.S.
Geological Survey standards and nomenclature

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STUDIES RELATED TO WILDERNESS

In accordance with the provision of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Studies and reports of all primitive areas have been completed. Areas officially designated as "wilderness," wild," or "canoe" when the Act was passed were incorporated into the National Wilderness Preservation System, and some of them are currently being studied. The Act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. This report discusses the results of a mineral survey of some of the land in the Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon, that is being considered for wilderness designation.

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STUDIES RELATED TO WILDERNESS--WILDERNESS AREAS

MINERAL RESOURCES OF THE CHARLES SHELDON WILDERNESS STUDY AREA, HUMBOLDT AND WASHOE COUNTIES, NEVADA, AND LAKE AND HARNEY COUNTIES, OREGON

SUMMARY AND INTRODUCTION

By U.S. Geological Survey and

U.S. Bureau of Mines

Summary

A mineral survey of the Charles Sheldon wilderness study area, located in Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon was conducted in 1974 and 1975 (fig. 1A, 1B, 1C). The mineral resource potential was evaluated by geological, geochemical, and geophysical studies by the U.S. Geological Survey, and by the examination of mines, prospects, and other mineralized localities by the U.S. Bureau of Mines. The investigation identified several areas of significant mineral potential within the study area which includes the Charles Sheldon Antelope Range and the Sheldon National Antelope Refuge (fig. 1B). The Virgin Valley area contains reserves of precious opal, small quantities of decorative building stone, and low-grade uranium resources. The investigation indicates that there are several areas of potential for the discovery at depth of mercury and for base and complex precious metal sulfide deposits within the study area. Reservoir temperatures, estimated from the analysis of thermal springs, suggest that the area has low-to-moderate potential for geothermal resources. The potential for oil, gas, or coal is very low.

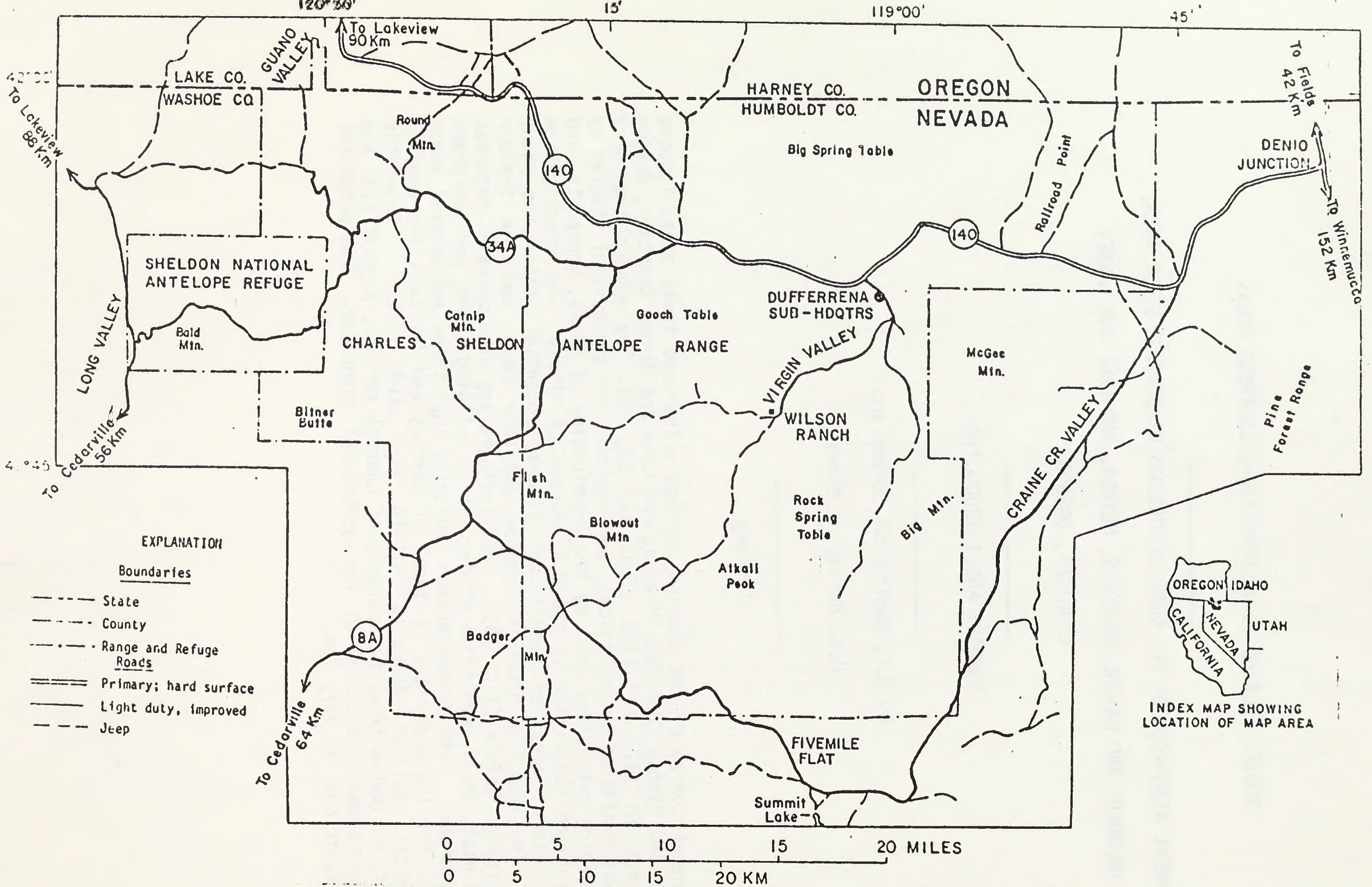
120°30'
15'
119°00'
45'
42°00'
To Lakeview 90 Km
To Fields 42 Km
To Winnemucca 152 Km
To Lakeview 88 Km
To Cedarville 56 Km
To Cedarville 64 Km
LAKE CO.
WASHOE CO.
GUANO VALLEY
HARNEY CO.
HUMBOLDT CO.
OREGON
NEVADA
DENIO JUNCTION
Round Mtn.
140
34A
8A
Big Spring Table
Railroad Point
SHELDON NATIONAL ANTELOPE REFUGE
Bald Mtn.
LONG VALLEY
Catnip Mtn.
CHARLES SHELDON ANTELOPE RANGE
Gooch Table
DUFFERRENA SUB-HDQTRS
VIRGIN VALLEY
WILSON RANCH
McGee Mtn.
Pine Forest Range
Bitner Butte
Fish Mtn.
Blowout Mtn
Alkali Peak
Rock Spring Table
Big Mtn.
CRAINE CR. VALLEY
Badger Mtn
FIVEMILE FLAT
Summit Lake
OREGON
IDAHO
NEVADA
UTAH
CALIFORNIA
INDEX MAP SHOWING LOCATION OF MAP AREA
EXPLANATION
Boundaries
State
County
Range and Refuge
Roads
Primary; hard surface
Light duty, improved
Jeep
0 5 10 15 20 MILES
0 5 10 15 20 KM

Figure 1A.--Map showing location and geographic features of the Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

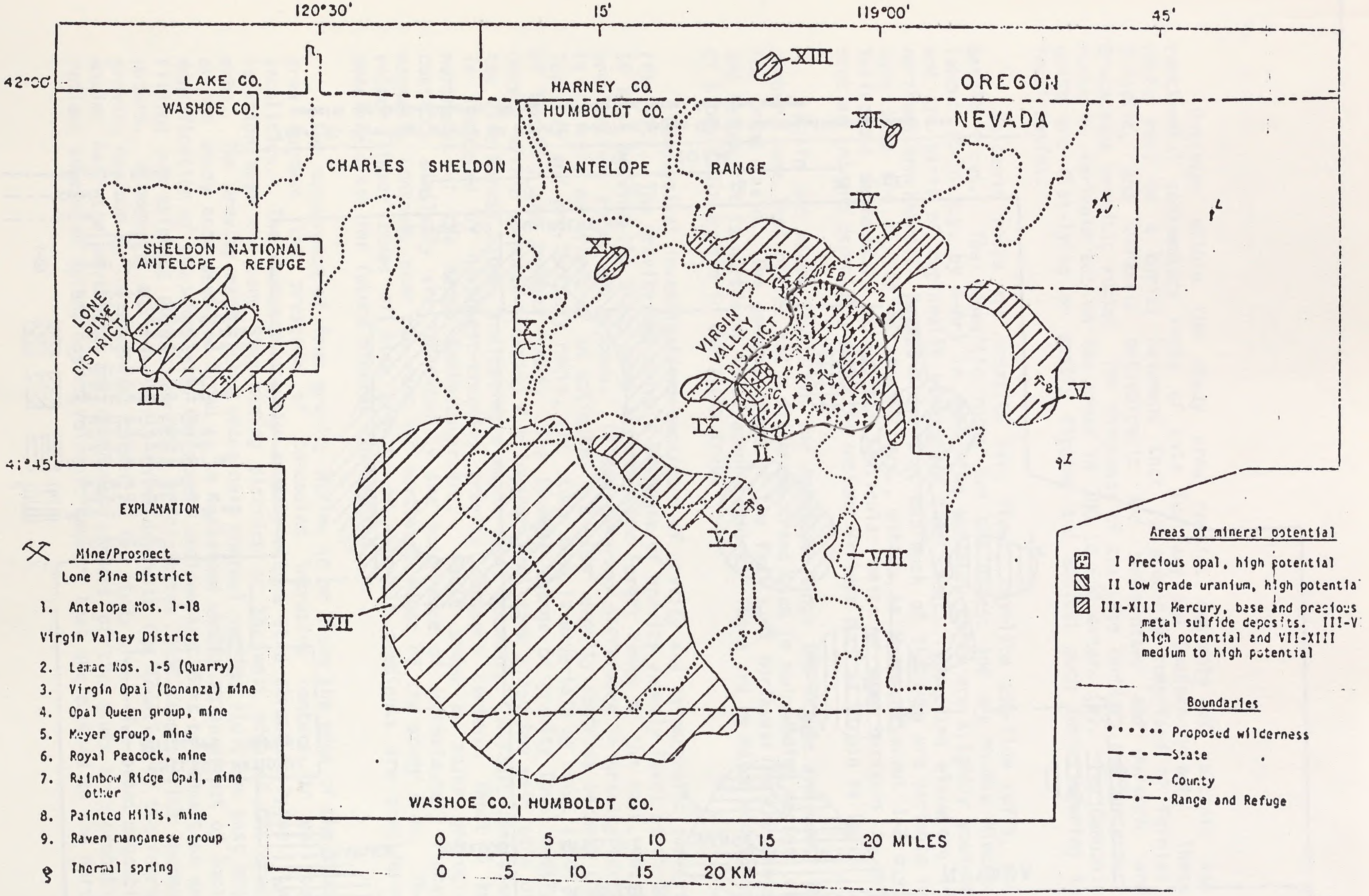
120°30'
15'
119°00'
45'
42°00'
41°45'
LAKE CO.
WASHOE CO.
HARNEY CO.
HUMBOLDT CO.
OREGON
NEVADA
CHARLES SHELDON ANTELOPE RANGE
SHELDON NATIONAL ANTELOPE REFUGE
LONE PINE DISTRICT
VIRGIN VALLEY DISTRICT
WASHOE CO.
HUMBOLDT CO.
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
EXPLANATION
Mine/Prospect
Lone Pine District
1. Antelope Nos. 1-18
Virgin Valley District
2. Lemac Nos. 1-5 (Quarry)
3. Virgin Opal (Bonanza) mine
4. Opal Queen group, mine
5. Meyer group, mine
6. Royal Peacock, mine
7. Rainbow Ridge Opal, mine other
8. Painted Hills, mine
9. Raven manganese group
Thermal spring
Areas of mineral potential
I Precious opal, high potential
II Low grade uranium, high potential
III-XIII Mercury, base and precious metal sulfide deposits. III-V high potential and VII-XIII medium to high potential
Boundaries
Proposed wilderness
State
County
Range and Refuge
0 5 10 15 20 MILES
0 5 10 15 20 KM

Figure 1B.--Map showing areas of potential mineral resources in relation to the proposed wilderness area, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

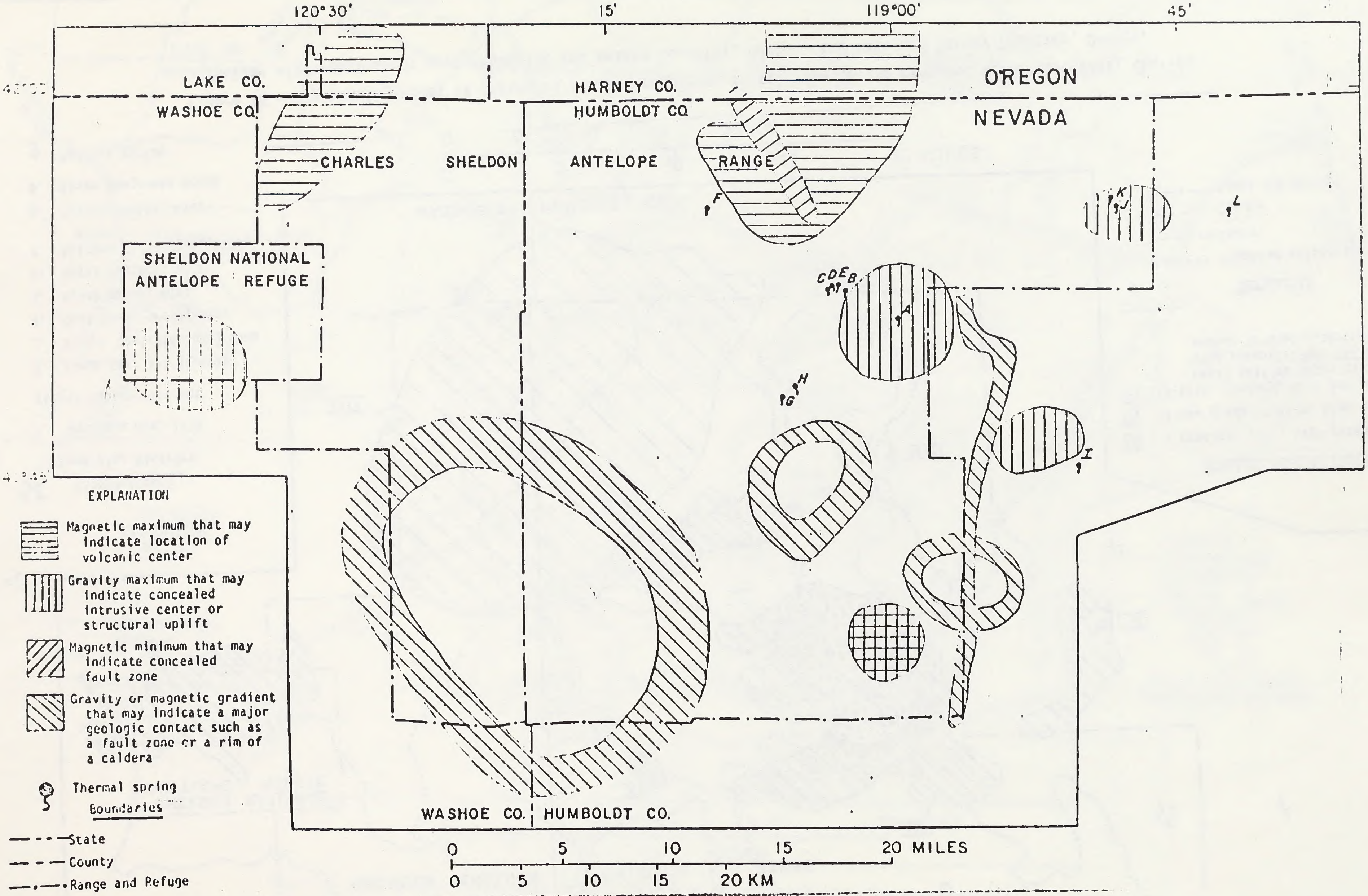
120°30'
15'
119°00'
45'
LAKE CO.
WASHOE CO.
HARNEY CO.
HUMBOLDT CO.
OREGON
NEVADA
CHARLES
SHELDON
ANTELOPE
RANGE
SHELDON NATIONAL
ANTELOPE REFUGE
A
B
C
D
E
F
G
H
I
J
K
L
WASHOE CO.
HUMBOLDT CO.
EXPLANATION
Magnetic maximum that may indicate location of volcanic center
Gravity maximum that may indicate concealed intrusive center or structural uplift
Magnetic minimum that may indicate concealed fault zone
Gravity or magnetic gradient that may indicate a major geologic contact such as a fault zone or a rim of a caldera
Thermal spring
Boundaries
State
County
Range and Refuge
0
5
10
15
20 MILES
0
5
10
15
20 KM

Figure 1C.--Prominent gravity and magnetic anomalies in the Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Outcrops within the study area consist entirely of volcanic and continental sedimentary rocks of Late Tertiary and Quaternary age. These rocks rest on a burial basement that is probably comprised of Permian, Triassic, and Jurassic metavolcanic and sedimentary and Jurassic and Cretaceous granitic rocks. The thickness of the Late Tertiary and Quaternary rocks is variable but on the order of 300 to 600 meters (m). The Cenozoic units are flat-lying or gently dipping and exhibit much interfingering in local basins.

Volcanic rocks are andesite lava flows, rhyolite ash-flow tuffs, and basalt flows. The andesitic rocks are the oldest and are Middle Miocene (about 15-16 m.y. by K-Ar) in age. The ash-flow tuffs are slightly younger and are parts of regionally widespread tuff sheets recognized elsewhere in northwestern Nevada. Basalt flows that cap much of the area are variable in age; some are as old as about 9 m.y., others as young as about 1-2 m.y. Tuffaceous sedimentary strata are lenticular units at many horizons in the section and are especially thick in ancient valleys such as Virgin Valley.

Basin and Range faults in the Antelope Range and Refuge are fewer in number, have less offset and a different trend than in surrounding regions of the Great Basin. The general trend of the faults is northwest in the Range and Refuge, it is northeast in adjacent regions. There are no major mountains of block fault origin in the study area.

Geophysical investigations consisted of gravity and aeromagnetic surveys (fig. 1C). The gravity map shows a decrease of gravity anomaly level of about 15 mgal between the study area and the Pine Forest Range to the east, where pre-Tertiary rocks are exposed. If the observed difference in gravity level is entirely an effect of an estimated 0.2 g/cm^3 density contrast between the Tertiary and pre-Tertiary rocks, the study area is underlain by about 1,800 m of Tertiary and younger rocks. The 15-mgal change of gravity level mostly occurs within a north-trending 4 kilometer (km) zone along the west edge of the Pine Forest Range, indicating a major fault boundary. A fault zone also is indicated by northwest-trending gravity contours centered about 6 km northeast of the Range Subheadquarters. Fault zones or major geologic contacts similarly are indicated by the occurrence of approximately linear magnetic contours near the east and northeast edges of the study area. The rather linear zones of high gravity or magnetic gradients are considered possible sites for future mineral exploration.

The occurrence of four gravity maxima in or along the edge of the study area suggest the presence of concealed intrusive centers or uplifted localities. The westmost gravity anomaly occurs at a structurally uplifted location near the Lone Pine mining district at the west edge of the study area. Two gravity maxima that occur near thermal springs along the east edge of the study area seem too broad to be explained wholly as an effect of local densification of the underlying tuffaceous sedimentary rocks by compaction and filling pre-existing pore space with precipitates from mineral-rich thermal waters. A magnetic maximum nearly coincides with the location of the fourth gravity maximum in the southeast corner of the study area. Two broad magnetic maxima near the northeast and northwest corners of the study area probably reflect concealed extensions of volcanic centers that are exposed to the north of the study area. The localities of gravity or magnetic maxima are considered possible sites for future possible mineral exploration, if such studies are undertaken.

Three prominent closed gravity minima along the south edge of the study area may reveal underlying calderas, which are masked by younger Tertiary rocks. The largest caldera is 17 by 25 km in size and, if the assumed underlying tuffaceous sedimentary rocks are on the average 0.2 g/cm^3 less dense than the surrounding volcanic rocks, the caldera extends to a depth of about 2.7 km. The areas along the edges of the postulated calderas are considered sites for possible future mineral exploration.

Based on geochemical sampling, anomalous concentrations of gold, mercury, antimony, arsenic, tungsten, molybdenum, manganese, and barium, and anomalous ratios of cadmium to zinc form dispersion patterns which delineate target areas for possible exploration for concealed mineral deposits. The targets of potential metallic resources within the study area are shown on figure 1B, No. III-XIII.

The south part of the Sheldon National Antelope Refuge (area III in fig. 1B) has potential for deposits of mercury and for concealed base and complex precious-metal sulfide deposits. A mercury anomaly covers a large part of the area. In addition, the anomalous concentration of the other elements mentioned above and the anomalous cadmium to zinc ratios form dispersion patterns that are contiguous with normal faults, and some magnetic and/or gravity highs.

Additional areas which may contain mercury and concealed base and complex precious-metal sulfide deposits are the areas encompassing the Subheadquarters (area IV in fig. 1B) and Painted Hills Mine (area V in fig. 1B). The geochemical dispersion patterns and their relationship to geological, geophysical, and thermal springs suggests that the Subheadquarters and Painted Hills mineralized areas may be joined at depth and may extend northwestward beneath younger volcanic rocks.

Area VI in figure 1B has a potential for similar metallic resources. Most of the valley of Hell Creek from its source to its junction with Virgin Creek is fault-controlled. The area near the junction of Hell Creek and Virgin Creek is contiguous to a geophysical anomaly. Anomalous amounts of mercury, arsenic, antimony, molybdenum, barium, gold, and manganese, anomalous ratios of cadmium to zinc, as well as several mercury prospects, seem to be associated with the faults and the western edge of a geophysical anomaly.

In the southwestern part of the Range gravity and magnetic anomalies of substantial size suggest the possible existence of a caldera or buried pluton. The widespread geochemical anomalies in this area are similar in size and magnitude to the mineralized McDermitt Caldera located approximately 132 km to the northwest in the Opalite Mining district. Whether a caldera or buried pluton is present in the area, the geochemical data suggest that area III shown on figure 1B has a possible potential for concealed mercury and complex precious metal sulfide deposits.

Areas VIII through XIII in figure 1B are other localities where anomalous concentrations of some of the elements discussed, anomalous ratios, and detectable gold occur in either stream sediments or rocks.

The study area contains two mining districts: the Virgin Valley near the eastern edge of the Range, and the Lone Pine near the southern part of the Refuge. Production from the study area is estimated to have been several million dollars, with nearly all production coming from the Virgin Valley district. Precious opal accounted for over 75 percent of the total. Significant deposits are at the Rainbow Ridge Opal, Royal Peacock, and Virgin Opal (Bonanza) mines in the Virgin Valley district (fig. 1B, No. I). Over 16,000 tonnes (t) of ornamental dimension stone valued at $66/t and about 14 t of fluorescent opalite have also been produced from the Virgin Valley district. A small amount of mercury reportedly was produced from the Lone Pine district.

One thousand six hundred fifty-six lode and 98 placer claims have been located within the area. Three hundred ninety-three claims are being actively worked.

Precious opal reserves and resources in the Virgin Valley district are estimated to be several million dollars in the following mines: Meyer group, Opal Queen group, Rainbow Ridge Opal, Royal Peacock, and Virgin Opal (Bonanza) (fig. 1B, No. I). Resources of ornamental dimension stone adjacent to the quarry in the Virgin Valley district are estimated to be more than 227,000 t of poor quality stone.

A submarginal uranium resource in tuffaceous sediments (fig. 1B, No. II) in the Virgin Valley district may contain 14 to 18 million t of uranium ore. Uranium may occur in tuffaceous sediments beneath younger volcanics adjacent to the Virgin Valley uranium occurrences (area II in fig. 1B) or in tuffaceous sediments associated with hot springs. Anomalous concentrations of some of the elements discussed, anomalous ratios, and detectable gold are associated with the known uranium occurrences.

Introduction

Location and access

The Charles Sheldon wilderness study area is located in the vicinity of the junction of California, Oregon, and Nevada in Humboldt and Washoe Counties, Nevada, and in Lake and Harney Counties, Oregon (fig. 1B). The study area includes the Charles Sheldon Antelope Range and Sheldon National Antelope Refuge which covers an area of approximately 2,140 km^2. In this report, these units will be referred to as "the Range" and "the Refuge". The Range and Refuge have been under the dual management of the Bureau of Sport Fisheries and Wildlife with headquarters in Lakeview, Oregon, and the Bureau of Land Management, with headquarters in Cedarville, California.

The study area is far from any large town. Virgin Valley, location of the Dufferrena Sub-headquarters and principal focus of activity in the Range, is 192 km from Winnemucca, Nevada (paved road), 153 km from Lakeview, Oregon (paved road), 142 km from Cedarville, California (90 km of gravel), and 82 km from Fields, Oregon (paved road). Denio Junction, with a combined gas station, motel, and restaurant, is 40 km away (paved road). In this report the Dufferrena Sub-headquarters will be referred to as the Sub-headquarters.

Access within the Range and Refuge is provided by a network of gravel and dirt roads, branching off from the paved route 140 (fig. 1A). Routes 8A and 34A are fair to good gravel roads and are also arterial routes. Other good gravel roads lead up Virgin Valley to the Wilson Ranch, between Badger and Blowout Mountains to Fivemile Flat and Summit Lake, and from Thousand Creek up Craine Creek Valley to Summit Lake.

Other roads in the Range and Refuge are rough and require 4-wheel drive. Access to the tops of Big Springs, Gooch, and Rock Springs Tables is poor.

Proposed wilderness

In 1971 certain portions of the Range, Refuge and adjacent areas were first proposed for wilderness status. By 1974, the proposed wilderness was expanded to include 8 units totaling 1,380 km^2 inside the Range and Refuge and 75 km^2 adjacent to it for a total of 1,455 km^2 (fig. 1B).

Wildlife and vegetation

Wildlife in the area is diversified, with antelope the species chiefly associated with the Refuge and Range. About 1,500 antelope are present at the peak period of winter use. Antelope of an interstate herd move in considerable numbers from Oregon to winter on the Refuge and Range. Summer populations are lower and usually total about 800 animals. Deer use the higher mountains extensively in summer and fall but many move off the Refuge and Range to winter on lower elevations farther east. The California bighorn sheep, originally indigenous, was extinct in the area by 1930. Sheep were reintroduced in 1968 and a small herd is becoming established in the Hell Creek drainage. Other native mammals include the coyote, bobcat, mountain lion and a host of smaller mammals characteristic of the region. Free-roaming horses and burros are also present in substantial numbers. Over 145 species of birds have been recorded. Birds vary seasonally in numbers and species but are always most abundant and diverse around springs or other water sources. The ponds, reservoirs and intermittent lakes total about 2750 surface hectacres (h) and are favored by migrating ducks, geese, swans and a variety of other waterbirds. Peak waterfowl populations may range up to 20,000. The native sage grouse and introduced chukar partridge are periodically abundant. Fishery resources are meager but Catnip Reservoir supports the endangered Lahontan cutthroat trout. It is reserved exclusively for restocking purposes. A number of amphibians and reptiles have been recorded, but like small mammals, no extensive inventory has ever been made.

Sagebrush and occasional grasses cover most of the valley areas. The table tops are covered with low sagebrush with occasional stands of big sagebrush and grass. Patches of mountain mahogany clothe some slopes at higher elevations giving way to willow, cottonwood and aspen in some drainages at lower elevations. Springs and seeps are often associated with small meadows.

Archaeological site

Early man's presence in the area dates to at least 10,000 years ago--to the great pluvial lakes of the Pleistocene Epoch. Caves such as the Last Supper Cave in Hell Creek Canyon provide a chronology of occupancy. This cave is the only known archaeological site of major size still intact.

Climate

The Charles Sheldon wilderness study area is classified by Sthraler (1969) as a middle-latitude desert climate, an interior region shut off by mountains from invasions of maritime air masses but dominated by continental tropical air masses in summer and continental polar air masses in winter. This climate has an annual temperature range from below -20°C in winter to over 37°C in the summer. The high altitude produces a daily summer temperature change frequently exceeding 10°C and an abnormally short frost-free period. Precipitation ranges from 13 to 38 cm annually, mostly falling as snow or winter rains. During the summer the relative humidity averages about 20 percent and may fall to 10 percent. The lower elevations may have an average growing season of about 75 days, and higher elevations may have frost in any month of the year.

Topographic and geologic setting

The Range and Refuge are in the northwestern part of the Great Basin section of the Basin and Range province (Fenneman, 1931, p. 326). Topographically, the Range and Refuge are mostly flat plateaus and rounded mountains, locally broken by steep scarps or cut by canyons. High fault scarps adjacent to flat, alluvial valleys, a characteristic feature of the Great Basin, are present both on the east (McGee Mountain-Craine Creek Valley) and west (Round Mountain-Guano Valley and Bald Mountain-Long Valley) sides of the area.

Several peaks (Catnip, Bald, Badger, Fish Creek Mountains) have summit elevations slightly over 2,100 m above sea level; total relief in the area is just over 900 m.

The Range and Refuge are on the southeast flank of a broad basin filled with sedimentary and volcanic rocks of Tertiary and Quaternary age that occupy northwesternmost Nevada, northeastern California, and south-central Oregon. Pre-Tertiary rocks adjacent to this basin to the southeast include Cretaceous granitic rocks and Permian, Triassic, and Jurassic volcanic and sedimentary rocks. These are found in the Pine Forest Range and Pueblo Mountains 10-15 km east from the Range boundary. Paleozoic and Mesozoic metamorphic and Cretaceous granitic rocks of the Sierra Nevada, Klamath and Blue Mountain provinces, all over 150 km, bound the southern, western, and northern sides of the basin.

This basin is dominated by northwest-trending normal faults. The structural break between this area and the northeast-trending fault block ranges to the east occurs at the Pine Forest Range and the Black Rock Desert to the south.

Previous studies

A reconnaissance map by D. A. Noble (1971, unpub.) covered the Humboldt County part of the Range and mapping for a thesis by W. G. Wendell (1970) included the Virgin Valley and McGee Mountain areas. The Washoe County part of the Range and Refuge is included on the county map by Bonham (1969).

Several investigators have reported the occurrence of valuable minerals in or near the Charles Sheldon wilderness study area.

Ross (1941, p. 23) reported on numerous mercury prospects and mines in the vicinity of the junction of California, Oregon, and Nevada. The nearest occurrence of cinnabar to the study area is in the Lone Pine district approximately 6.4 km southwest of the headquarters of the Sheldon National Antelope Refuge (fig. 1B). The main occurrences of mercury are just south of the Refuge, although several small prospects are just within the boundary (Holmes, 1965, p. 269). Sporadic exploration since 1929 has not resulted in production. Bonham (1969, p. 70) reported that trace amounts of gold occur with cinnabar in the Lone Pine district; however, mineable amounts of gold were not found by prospecting.

Wendell (1970, p. 109) indicated that cinnabar was found along a major fault which is adjacent to the Painted Hills mine (fig. 1B). He reported that Recent movement along one of the associated faults is indicated by steam emission; temperatures in a drill hole within the fault zone were 55°C at a depth of 60.9 m (Wendell, 1970, p. 98).

Staatz and Bauer (1951) reported the discovery of uraniferous opal in the Virgin Valley district (fig. 1B). This district has produced some of the best gem opal found in the United States; however, no production of uranium has been reported.

Harold Stager (written commun., 1976) reported visiting the Raven manganese claims (fig. 1B) in June 1959. The deposit consists of beds of cryptomelane interbedded with volcanic ash, silt, fine sand, and diatomite. No production has been reported from these claims.

The U.S. Geological Survey's Mineral and Water Resources of Nevada (1964) mentions fire opal, dimension stone, and uranium occurrences in Virgin Valley.

Present investigations

A new geologic map of the Range, Refuge and vicinity was prepared for the present mineral resource study (pl. 1). It includes all areas mentioned in the various wilderness proposals. In much of the Humboldt County portion, the map is identical with that of Noble (1971, unpub.); elsewhere it differs.

Field mapping was done by R. C. Greene in October 1974, May and June, 1975, and by R. C. Greene assisted by K. L. Stark in July 1975. Uranium deposits were investigated by J. E. Peterson in May 1975.

The present geochemical investigations were conducted by John B. Cathrall, assisted by David F. Siems, Steve Taylor, and Dwight Rhiner, during the summer of 1975. About six weeks were spent in the field collecting samples and examining areas reported to be mineralized. A total of 1280 rock and stream-sediment samples were collected and analyzed in a mobile laboratory in the field by Elmo F. Cooley, George L. Crenshaw and James Hurrell. These results were supplemented by additional analyses in the U.S. Geological Survey laboratories in Denver, Colo.

Analytical data, type of materials sampled, and coordinates of sample localities were entered into the U.S. Geological Survey computer data storage system RASS (Rock Analysis Storage System) from a field-based computer station operated by Ricke J. Smith and Mary L. Marchitti. The analytical data were retrieved from the RASS system and were analyzed statistically by a variety of computer programs. These programs consisted of graphical analyses, simple linear correlation coefficients among logarithms, and cumulative frequency plots.

Listing of analytical results for rock, stream-sediment, water, and algae samples; calculated minimum thermal-reservoir temperatures; and the statistical summary of the analytical results for rock and stream-sediment samples are available in Open-File Report 77-403 (Cathrall and others, 1977). Sample sites for stream-sediment and rock samples are shown on the plates of this report.

A gravity survey was carried out by S. L. Robbins and K. D. Holden in October 1975. Interpretations of geophysical data were done by Donald Plouff.

No systematic attempt was made by the Geological Survey to sample prospects or claims for quantitative estimation of mineral content, as these aspects were covered by personnel of the U.S. Bureau of Mines under the supervision of E. T. Tuchek assisted by F. L. Johnson and M. D. Conyac.

Acknowledgments

The field party was headquartered at the Sub-headquarters of the Range and at the adjacent Virgin Valley campground. We appreciate the many courtesies extended by the ranger at the Sub-headquarters and his wife, Henry and Happy John, who also provided a historical sketch of the area. The authors extend appreciation to claim holders, property owners, and local residents Ed and Louise Mitchell, and Harry and Joy Wilson. Special acknowledgment is due Harry Wilson and Keith Hodson for providing historical background data on precious opal. Special thanks are due to our colleagues who assisted in retrieving and restoring critical geochemical data destroyed by the fire at the Denver Federal Center in March of 1976.

MINERAL RESOURCES OF THE CHARLES SHELDON WILDERNESS STUDY AREA, HUMBOLDT AND WASHOE COUNTIES, NEVADA, AND LAKE AND HARNEY COUNTIES, OREGON

GEOLOGIC APPRAISAL

By R. C. Greene, U.S. Geological Survey

Introduction

The Charles Sheldon Antelope Range and Sheldon National Antelope Refuge are underlain entirely by volcanic and continental sedimentary rocks of late Tertiary and Quaternary age. The rocks are flat-lying or gently dipping, and lap in and out against each other. In most areas the stratigraphic succession can be easily deciphered. The rocks are broken by numerous normal faults (pl. 1).

Stratigraphic nomenclature

Both formal and informal names for rock units which have already appeared in the literature are adopted wherever possible. A few local units are left unnamed and several new informal names are introduced.

Canyon rhyolite is an old name introduced by Merriam in 1910. Idaho Canyon tuff, Summit Lake tuff, tuff of Big Mountain, tuff of Trough Mountain, and Soldier Meadow tuff were proposed by Noble and others in 1970 and are used here. New informal names include the following: rhyolite of Cottonwood Canyon, andesite of Round Mountain, andesite of Bald Mountain, rhyolite of Catnip Mountain, rhyolite of Badger Mountain, rhyolite of Nut Mountain, basalt of Catnip Creek, and basalt of Railroad Point.

Stratigraphy

Introduction

The rock units shown on plate 1 may be divided into three broad sequences. The lowermost of these units consists of the andesite of Round Mountain, and generally correlative older units of rhyolitic to basaltic composition, which appear only in windows (isolated areas surrounded by younger rocks). The middle sequence is the main sequence of rhyolites and welded tuffs with intercalated sediments (Idaho Canyon tuff through rhyolite of Nut Mountain). The upper sequence consists of basalts which cap the tables on the east and the broad areas on the west, plus immediately underlying and intercalated sediments and overlying surficial deposits.

Lower sequence

Rhyolite of Cottonwood Canyon

Trct

The rhyolite of Cottonwood Canyon occurs on the steep, west-facing scarp separating Bald Mountain and the adjacent plateau from Long Valley. It may be as much as 330 m thick and appears to underlie the andesite of Bald Mountain.

The rhyolite of Cottonwood Canyon unit contains both rhyolite and quartz latite. Exposed low on the scarp and along the road as it enters Cottonwood Canyon is a medium- to light-gray quartz latite with banded to mottled texture containing trace amounts of plagioclase, hornblende, biotite, and magnetite phenocrysts in a groundmass of plagioclase microlites and cryptocrystalline material. Light-gray rhyolite is exposed higher on some spurs. It contains sparse phenocrysts of quartz, alkali feldspar, plagioclase, biotite, and magnetite in a cryptocrystalline groundmass.

Andesite of Round Mountain

Tar

Andesite of Round Mountain underlies Round Mountain and several square kilometers to the northwest, including part of the major scarp separating the Round Mountain-Antelope Butte area from Guano Valley. It extends as far north as Route 140 where it curves west to cross Guano Valley. This unit is at least 270 m thick on the scarp bordering Guano Valley, with an additional 140 m on Round Mountain.

A dense uniform medium- to dark-gray greenish speckle platy andesite is the predominant rock on Round Mountain. A greenish speckle is characteristic. The rock contains 1 to 30 percent microphenocrysts of plagioclase and trace amounts of clinopyroxene, and, locally orthopyroxene, olivine, and magnetite in a groundmass of alined plagioclase microlites, and clinopyroxene, magnetite, and glass.

In addition to the platy andesite, there is a large amount of vesicular, cindery, andesitic agglomeratge or breccia exposed in the scarp overlooking Guano Valley, particularly along Highway 140. Near the short canyon that joins Guano Valley at the state line, tuffaceous sedimentary rocks interbedded with the andesite are also prominent. Many of the sedimentary layers are baked red where in contact with andesite.

Andesite of Bald Mountain Tab

Bald Mountain, Bald Mountain Canyon, and a portion of the scarp bordering Long Valley directly west of the now abandoned Refuge headquarters is composed of the andesite of Bald Mountain. It is about 330 m thick on the main scarp, with Bald Mountain adding 120 m more. The mineralization of the Lone Pine district in Bald Mountain Canyon is entirely in this unit.

The most typical rock is grayish-red to brownish-gray andesite or dacite with prominent rudely alined plagioclase phenocrysts that form 5 to 10 percent of the rock. Other phenocrysts present in trace amounts include olivine, clinopyroxene, othopyroxene, hornblende, biotite, and magnetite. The groundmass is mostly plagioclase microlites and glass, with olivine, clinopyroxene and apatite locally recognizable. Some of the andesite is vesicular, and black vitrophyre is present locally.

The unit also contains interbedded tuffaceous sedimentary rocks. These are poorly exposed on Bald Mountain, but crop out in Bald Mountain Canyon and on the scarp adjacent to Long Valley (fig. 2).

Dacite Td

This unnamed unit is exposed in two small areas in the flats immediately southwest of Alkali Reservoir. It consists of dense gray dacite, inflated gray dacite, and red cinder agglutinate. Some of the dacite is porphyritic and contains a few percent each of quartz and plagioclase phenocrysts, trace amounts of clinopyroxene and magnetite phenocrysts, and a groundmass of plagioclase and glass with minor clinopyroxene and magnetite.

Porphyritic basalt Tbp

Porphyritic basalt is exposed at the mouth of Idaho Canyon and to the south near the southeast corner of the Range. The porphyritic basalt is characterized by large plagioclase phenocrysts and is similar to basalts on Steens Mountain north of Denio and in the Bilk Creek and Trout Creek Mountains to the east.

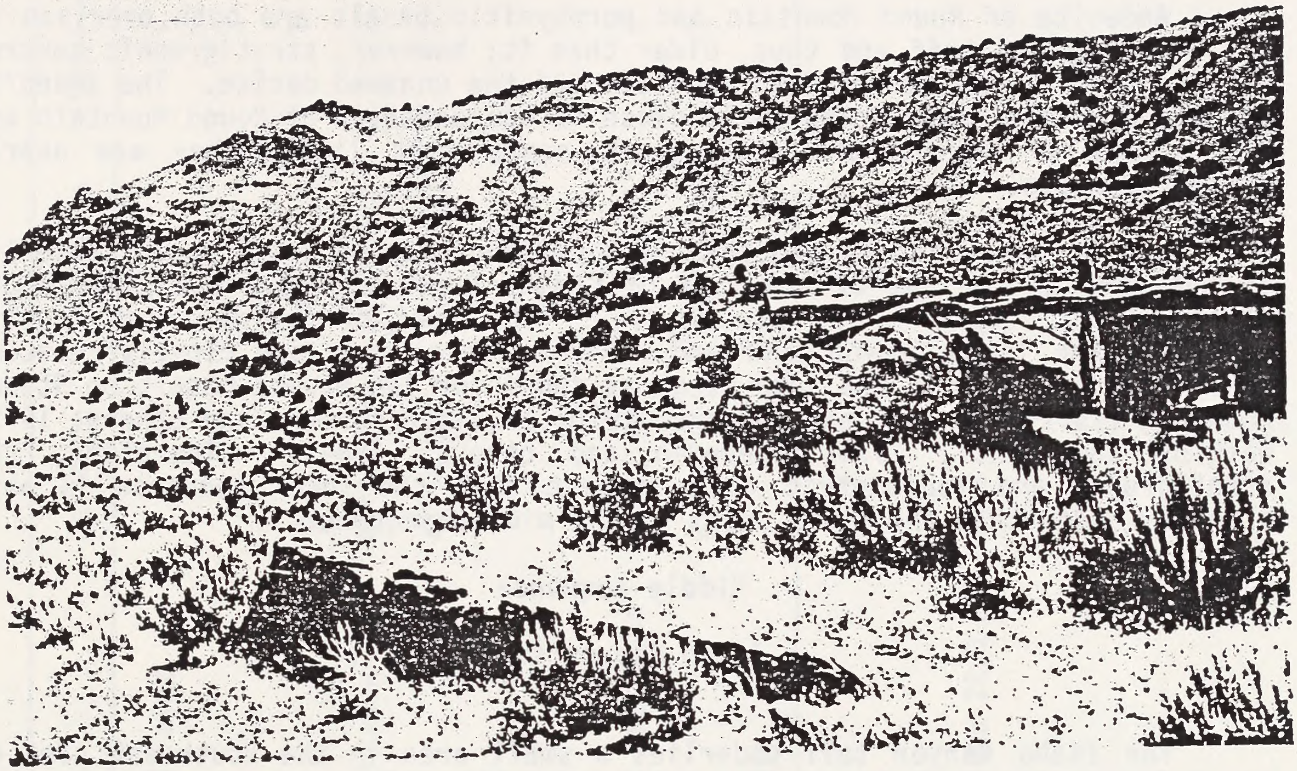

Figure 2.--Scarp east of Long Valley (Calcutta Lake) at Refuge boundary. Exposed in scarp is andesite of Bald Mountain, with abundant interbedded tuffaceous sedimentary rocks, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Age of lower sequence

Andesite of Round Mountain and porphyritic basalt are both overlain by the Idaho Canyon tuff and thus, older than it; however, stratigraphic control is poor on the andesite of Bald Mountain and the unnamed dacite. The andesite of Bald Mountain is geographically close to the andesite of Round Mountain and has a similar structural setting, it seems most likely they are nearly contemporaneous.

A K-Ar date for the andesite of Round Mountain 15.3±0.9 m.y. (table 1), is the same as the age of the tuff of Craine Creek 15.7±0.5 m.y., Noble and others, 1970, table 1 of this paper). The tuff of Craine Creek locally underlies the Idaho Canyon tuff and Noble believes they are closely related. These ages are also in the same range as those for the Steens basalt on Steens Mountain (15.1±0.3, Gunn and Watkins, 1970; 15.3±1.0, Greene and others, 1972; Watkins and Baksi, 1974; Evernden and others, 1964). Therefore, the stratigraphy and radiometric ages suggest that the lower sequence is only slightly older than the lower units of the middle sequence.

Middle sequence

Idaho Canyon tuff

Tic

The Idaho Canyon tuff underlies a small area in the southeast part of the Range, which includes the type locality (fig. 3), and a much larger area in the north-central part. It is about 120 m thick at the type locality (Noble and others, 1970) and probably 60-120 m thick to the north, where partial sections are well exposed in scarps and canyons such as Catnip Canyon.

The Idaho Canyon tuff consists mostly of densely welded devitrified tuff. Most is streaky banded medium gray to light brownish gray and contains very narrow lenticular gas cavities. In certain zones the rock is very inflated, containing spherical cavities, locally partially filled to form lithophysae. In the northern area of the unit, a three-fold sequence--dense/lithophysal/dense--is characteristic.

The tuff is sparsely porphyritic; principal phenocrysts are alkali feldspar (2-5 percent) and quartz (trace to 2 percent). Other phenocrysts in trace amounts include fayalite, magnetite, and other altered ferromagnesian minerals. The groundmass is cryptocrystalline with local weak granophyric texture and local indistinct shard forms. At only one outcrop in the northern part does vitric tuff have prominent shard and pumice textures.

Table 1. K-Ar ages on some rock units in and near the Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon

Unit	Age, m.y.	Locality	Latitude	Longitude	Reference
Basalt of Railroad Point	1.58±0.2	south end of Railroad Point			1
Basalt of Catnip Creek	8.84±1.1	rim of Guano Valley			1
	9.87±1.2	Gooch Table			1
Soldier Meadow tuff	14.7 ±0.5	southeast of Soldier Meadow	41°21'25"	119°04'40"	2
Canyon rhyolite glass	13.7 ±1.4	Thousand Creek gorge	41°54'00"	118°57'00"	3
Canyon rhyolite feldspar	16.3 ±1.3				
Canyon rhyolite feldspar	22.3 ±1.8				
Summit Lake tuff	15.1 ±0.5	Craine Creek - Summit Lake Road	41°43'10"	119°01'15"	2
Tuff of Craine Creek	15.7 ±0.5	Craine Creek	41°35'15"	118°55'00"	2
Andesite of Bald Mountain	15.3 ±0.9	northside Bald Mountain			1

[1] New dates by E. H. McKee, U.S.G.S., Menlo Park.

[2] Noble and others, 1970.

[3] McKee and Marvin, 1973 - In light of stratigraphic relations 22.3 m.y. date is unreasonable.

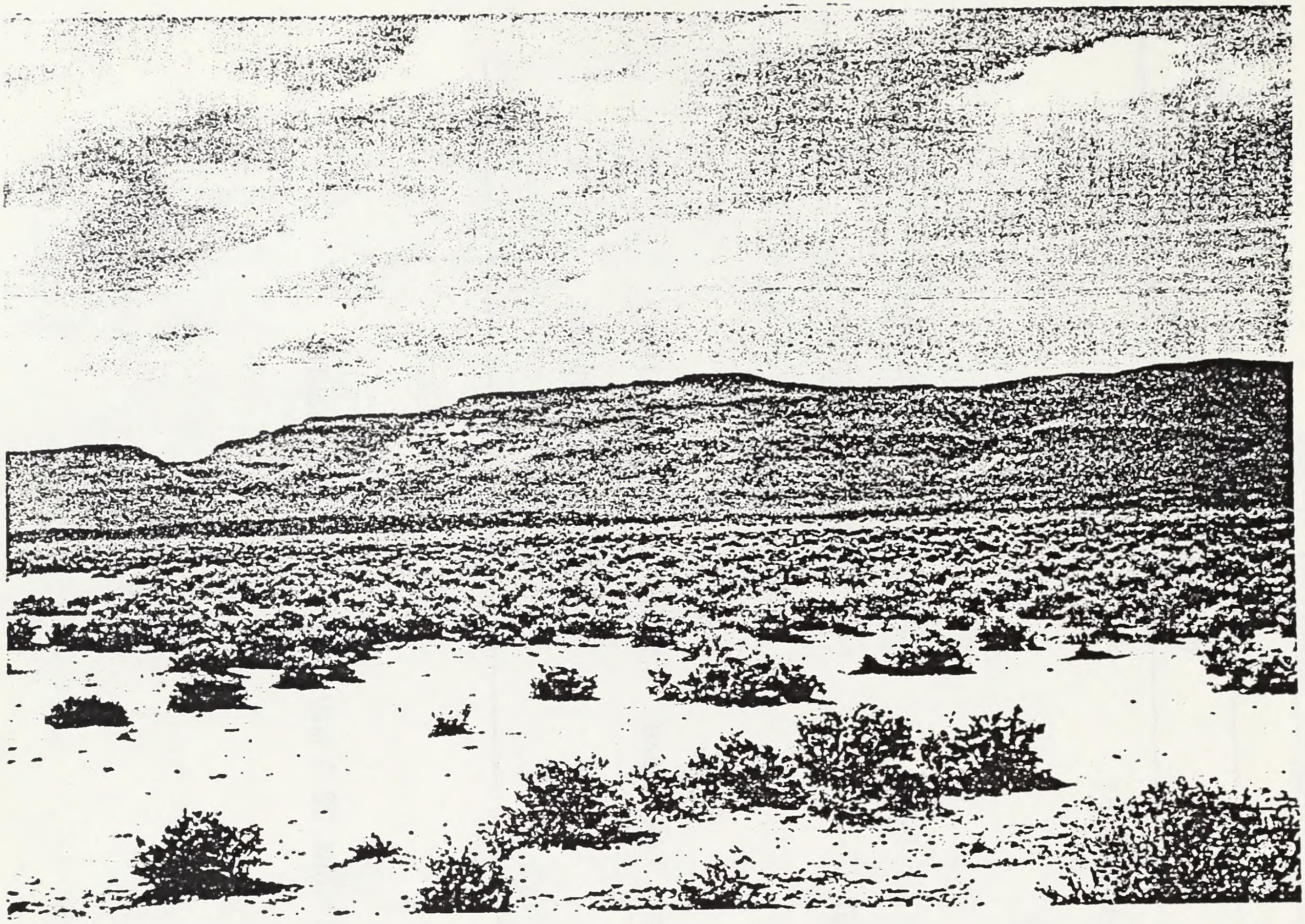

Figure 3.--Scarp of Big Mountain from Craine Creek Valley, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon. Mouth of Idaho Canyon at left.

Summit Lake tuff

Tsl

The Summit Lake tuff is present in a small area near Idaho Canyon in the southeast part of the Range. The type locality is along the road between Craine Creek Valley and Summit Lake (sec. 35, T. 43 N., R. 26 E.); the unit is about 30 m thick (Noble and others, 1970).

The rock is light brownish gray to pale yellowish brown, commonly mottled and contains abundant phenocrysts and rock fragments. The phenocrysts are alkali feldspar and plagioclase (10-15 percent total) with trace amounts of quartz, clinopyroxene, hornblende, biotite, and magnetite. Groundmass is part vitric and part devitrified, with shard and pumice textures prominent.

Red welded tuff

Trw

A striking reddish brown or "brick red" dense welded tuff crops out along the east face of McGee Mountain. It occurs high in the section of sediments beneath the Canyon rhyolite. The tuff contains trace amounts of alkali feldspar phenocrysts in a cryptocrystalline groundmass with compressed shard texture.

Canyon rhyolite

Tcr

The Canyon rhyolite is an extensive unit in the east part of the Range. It underlies much of McGee Mountain, Big Mountain, and the hills both north and south of Gooch Table. The type locality is Thousand Creek Gorge, secs. 24 and 34, T. 46 N., R. 26 E., (Merriam, 1910).

The Canyon rhyolite is a resistant rock which forms many bold cliffs, as on McGee and Big Mountains, and vertical walled canyons such as Thousand Creek Gorge and parts of Virgin and Sagebrush Creeks. Lobate pressure ridges, mostly stripped of former sediment cover, show strikingly on areal photographs and from certain vantage points in the field.

The rhyolite is characteristically streaked and mottled grayish red, brownish gray, and medium to light gray. Banded, brecciated, lithophysal and various vesicular to cavernous textures are common. Much of the rock is silicified, containing secondary quartz and agate. Phenocrysts, where present, are minute and inconspicuous. They include trace amounts of quartz, alkali feldspar, fayalite, and magnetite. Groundmass is a cryptocrystalline aggregate of alkali feldspar and silica minerals, dominated by radial texture.

Tuffaceous sedimentary rocks and welded tuffs are interbedded with the rhyolite of this unit, particularly on McGee and Big Mountains. The welded tuff is separately mapped and is described below (tuff of Big Mountain). The sedimentary rocks are also similar to those separately mapped and described below (tuffaceous sedimentary rocks, Tst of pl. 1).

The Canyon rhyolite is about 120 m thick at the mouth of Thousand Creek Gorge. The section thickens to the south as more sedimentary rocks and the tuff of Big Mountain are interbedded with it, reaching about 300 m on the scarp below the summit of McGee Mountain. The rhyolite may be as much as 300 m thick on Big Spring Butte and 320 m thick in the hills south of Gooch Table.

Rhyolite dike Tcrd

A dike of rhyolite similar to the Canyon rhyolite crops out prominently on the northeast end of Big Mountain, crosscutting the sedimentary rocks underlying the Canyon rhyolite. It was obviously a feeder for part of the Canyon rhyolite.

Rhyolite vitrophyre Tcrv

Five partly coalescing domal masses of rhyolite vitrophyre are alined at about N. 65° E. in the Sagebrush Creek Valley (sec. 24, T. 45 N., R. 26 E.) They appear to be spatially related to the Canyon rhyolite, but have significantly different phenocryst mineralogy. The rather porous rock is medium light gray and contains trace amounts of each of the following phenocrysts: alkali feldspar, plagioclase, clinopyroxene, hornblende, biotite, and magnetite. Groundmass consists of about half plagioclase microlites and half glass.

Tuff of Big Mountain Ttb

The tuff of Big Mountain is present in several areas on McGee and Big Mountains. The type locality is on the east-facing scarp of Big Mountain (fig. 3) near the mouth of Idaho Canyon, where it forms prominent cliffs capping the scarp (Noble and others, 1970). It is about 240 m thick at this locality, but much thinner where interbedded with the Canyon rhyolite.

The unit consists of partially welded to densely welded tuff. At the type locality, the rock is pinkish gray and porous; on McGee Mountain it is denser and banded pale brown and light gray. The tuff contains trace amounts to 2 percent each of phenocrysts of alkali feldspar and quartz, and trace amounts of clinopyroxene and magnetite. Groundmass is cryptocrystalline; comby and radiating devitrification textures commonly obliterate the shard texture.

Rhyolite of Catnip Mountain Trc

The rhyolite of Catnip Mountain underlies a large area centered at Catnip Mountain (fig. 4) and reappears discontinuously to the southeast, notably Virgin Creek Canyon at the mouth of Hell Creek (fig. 5), and the hills north of Fivemile Flat. It is about 430 m thick on Catnip Mountain.

Rhyolite of this unit is characteristically finely banded medium light to very light gray, with fine porosity in the lighter bands. The banding is commonly steeply dipping or intricately folded. Platy and columnar jointing are both common, as are gas cavities of various sizes. The rhyolite crops out in the canyons of Catnip Mountain and Virgin Creek (fig. 5), and at higher elevations on Catnip Mountain.

The rhyolite is most commonly aphyric, but locally contains trace amounts of alkali feldspar and latered mafic mineral phenocrysts.

An unusual exposure of the base of this unit occurs in a cliff overlooking Hell Creek about 1.6 km west of Virgin Creek. Here, a basal zone of densely welded tuff with good shard and pumice textures about 1.2 m thick apparently grades up to an irregular lithophysal zone about 4.5 m thick, which in turn grades into normal banded rhyolite.

A distinctive feature of the rhyolite of Catnip Mountain is the presence of obsidian nodules. These are not seen in outcrop, but are scattered irregularly on the surface underlain by the unit. The obsidian is black, translucent, and structureless.

Tuff of Trough Mountain Ttt

The tuff of Trough Mountain was mapped in a small area directly west of Fivemile Flat. More is present to the southwest (Noble and others, 1970). The tuff is dense and strongly welded, light olive gray to dark yellowish brown, and characterized by a brecciated texture. Phenocrysts include trace amounts of alkali feldspar, quartz, and magnetite.

Rhyolite of Badger Mountain Trb

The rhyolite of Badger Mountain underlies a large area including Badger, Fish Creek, Blowout, and Mahogany Mountains that extends eastward to the canyon of Virgin Creek (fig. 6). Although these mountains are generally rounded in form, ridge crests and cliff lines provide abundant outcrop.

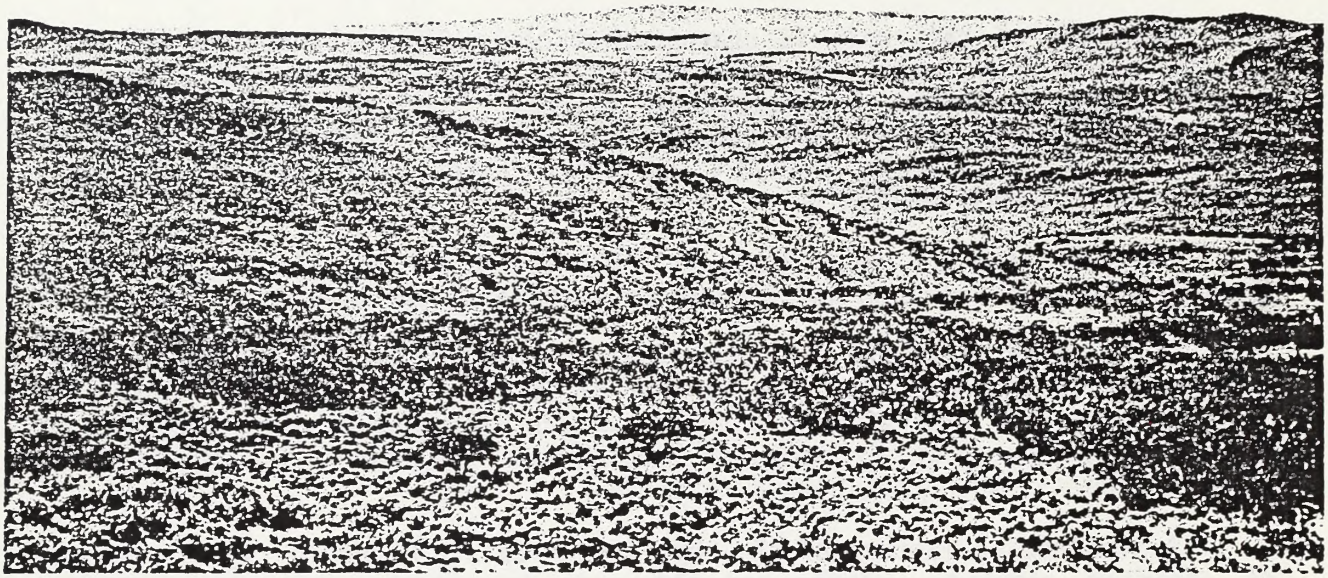

Figure 4.--View north from Badger Mountain, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon. Foreground underlain by rhyolite of Badger Mountain. In middle distance Badger Creek valley underlain by tuffaceous sedimentary rocks with local basalt caps, right side is Fish Creek Mountain underlain by rhyolite of Badger Mountain. Far distance in center is Catnip Mountain, underlain by rhyolite of Catnip Mountain. Extreme distance on left--Hart Mountain.

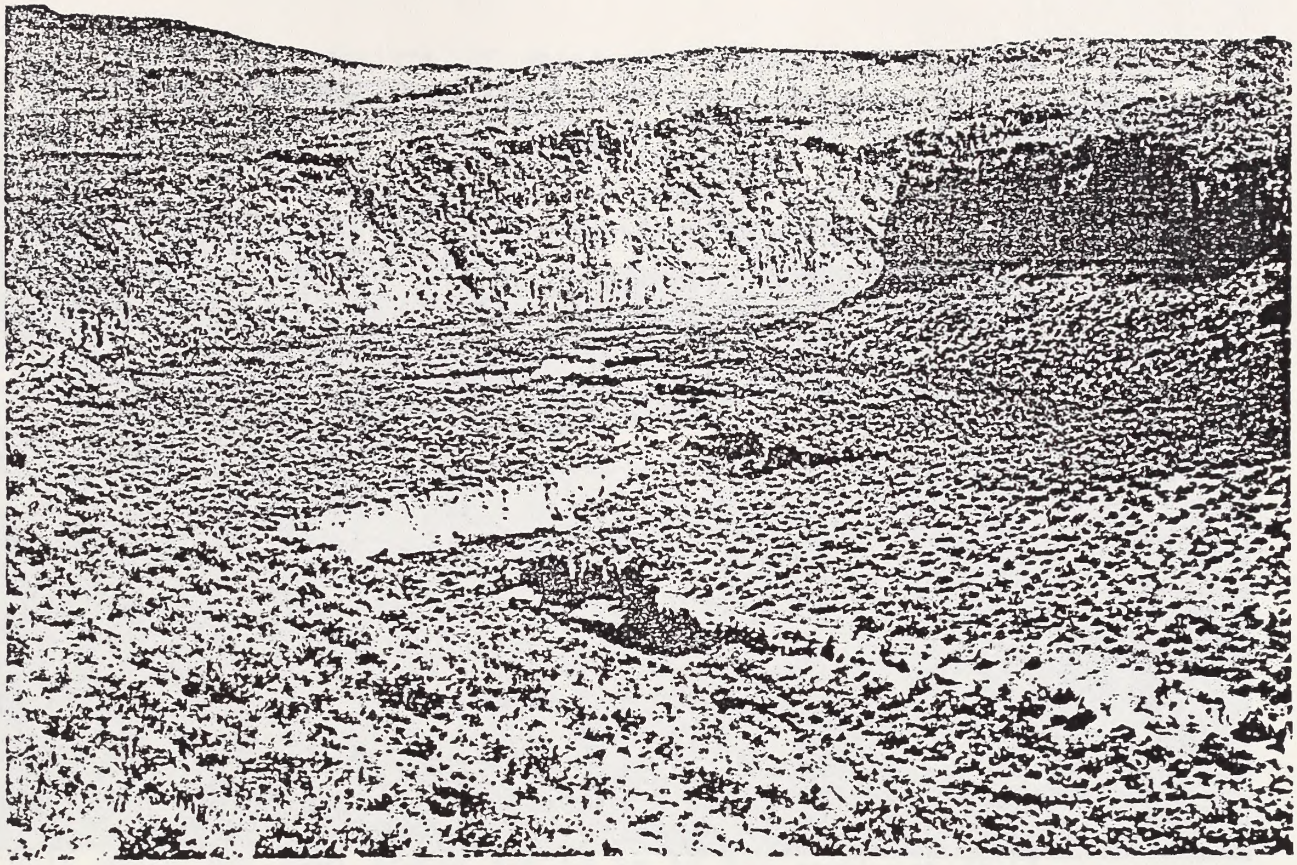

Figure 5.--Open canyon of Virgin Creek south of Virgin Valley, near mouth of Hell Creek, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon. Main canyon wall is of rhyolite of Catnip Mountain, note whitish weathering and well developed columnar joints. Floor of canyon is flat, has been filled with alluvium to considerable depth, small inner canyon is cut in alluvium.

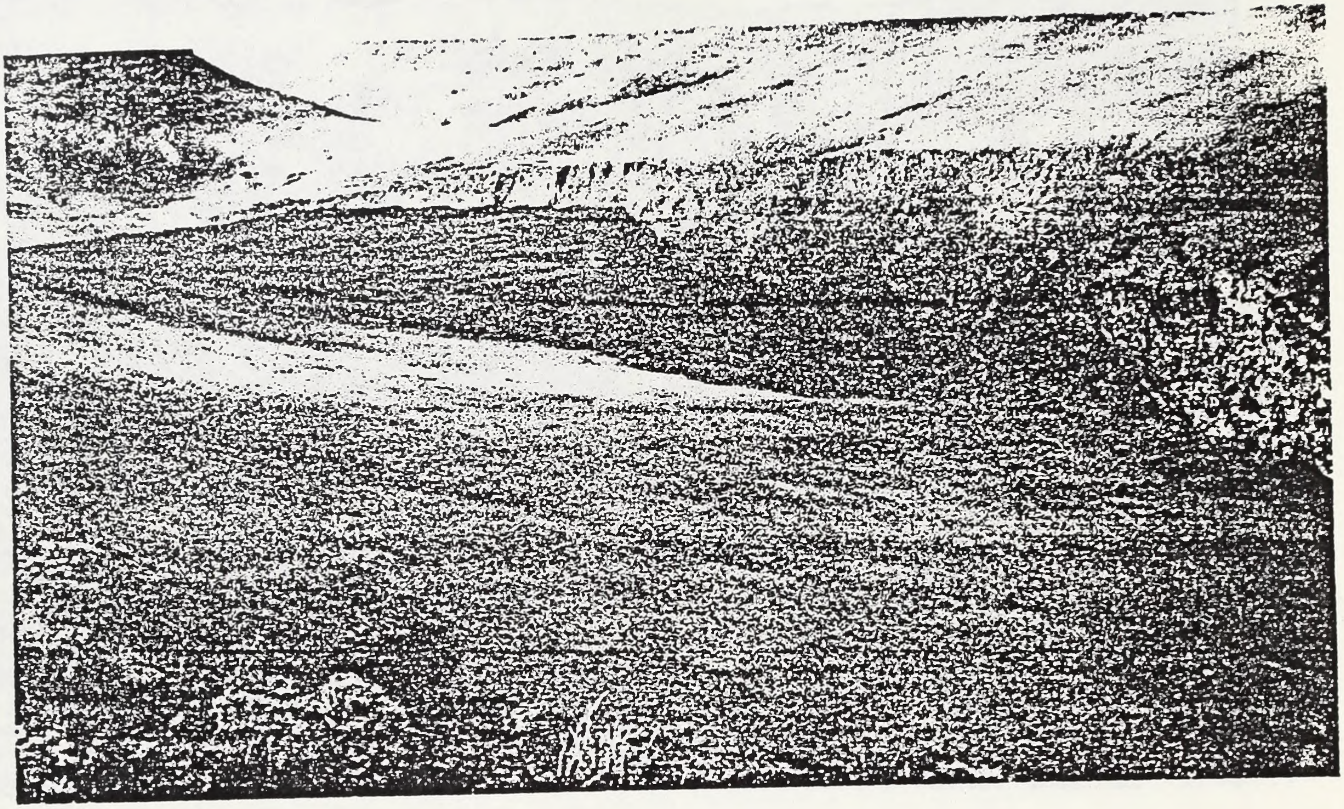

Figure 6.--Canyon of Virgin Creek south of Virgin Valley, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon. A double canyon. Photographer is standing on rim of upper part of rhyolite of Badger Mountain, below him is slope underlain by tuffaceous sedimentary rocks, followed by inner canyon cut in lower part rhyolite of Badger Mountain. Across canyon slope is of tuffaceous sedimentary rocks capped by basalt of Rock Springs Table.

This unit consists of abundantly porphyritic rhyolite. Colors are varied, but are mostly medium to light gray and brownish gray. Flow-banded textures with considerable porosity in the lighter bands are characteristic. Most of the rhyolite contains 2-10 percent quartz phenocrysts (dark in hand specimen) and 5-20 percent alkali feldspar phenocrysts, with trace amounts of clinopyroxene and magnetite phenocrysts. Groundmass is cryptocrystalline with granular or radiating texture.

Some of the rhyolite has vitric groundmass. This rock is dark gray with a greenish or yellowish mottle, dense, and abundantly porphyritic. Phenocrysts include 0-2 percent alkali feldspar, 0-3 percent quartz, 5-20 percent plagioclase, and trace amounts of clinopyroxene, magnetite, biotite, and hornblende.

The rhyolite of Badger Mountain is about 300 m thick on Badger and Fish Creek Mountains (fig. 4). In the canyon of Virgin Creek (fig. 6) it is split into distinct upper and lower parts. A tongue of the Soldier Meadow tuff separates them locally. The upper part is about 300 m thick and the lower part about 180 m thick.

Soldier Meadow tuff

Tsm

The Soldier Meadow tuff is present at scattered localities in the south part of the Range. These are the northernmost occurrences of this extensive unit which has been traced for 60 km to the southwest (Noble and others, 1970). Thickness in the area mapped is 30-60 m.

The Soldier Meadow tuff characteristically crops out along cliff lines which show widely spaced vertical joints. The rock is mostly light to very light brownish gray, somewhat porous, and abundantly porphyritic. Phenocrysts include 3-10 percent quartz, 10-20 percent alkali feldspar and traces of magnetite and altered ferromagnesian minerals. Groundmass is granular with shard texture weakly preserved. Pumice lumps in various stages of collapse are also characteristic.

Rhyolite of Nut Mountain

Trn

The rhyolite of Nut Mountain was mapped in a small area near the southwest corner of the Range, both on Nut Mountain and an adjacent ridge. Its extent is poorly known. It is a heterogeneous unit, consisting of rhyolite flows and both sparsely and abundantly porphyritic welded tuffs.

The rhyolite flows are light gray to light brownish gray aphyric rocks which resemble the rhyolite of Catnip Mountain. The sparsely poprhyritic welded tuff is medium gray to brownish gray and contains trace amounts of phenocrysts of alkali feldspar, plagioclase, augite, and magnetite. The abundantly porphyritic welded tuff is brownish gray and contains about 15 percent alkali feldspar phenocrysts and trace amounts of plagioclase, biotite, and magnetite. Shard texture is prominent in the welded tuffs.

Tuffaceous sedimentary rocks Tst

Tuffaceous sedimentary rocks are found at all levels of the middle sequence and are mapped where thick enough to show on the scale of the map (pl. 1). In the west part of the Range, tuffaceous sedimentary rocks are high in the section and are interlayered with the basalt of Catnip Creek of the upper sequence.

The tuffaceous sedimentary rocks are mostly claystones and poorly sorted coarser rocks, all weakly consolidated. They range widely in color from white through various light grays, brown, and reds. The coarser rocks consist mainly of volcanic rock fragements, plagioclase grains, pumice lumps and glass shards wih clay matrix. White pumice or shard (ash) beds are locally present. Palagonite tuff is abundant in this unit around Post Camp Spring south of Fish Creek Mountain. The palagonite tuff is similar to that in the vent areas described below except that the bedding is prominent, and is interlayered with light-colored tuffaceous sedimentary rocks.

Tuffaceous sedimentary rocks are well exposed in Virgin Valley (fig. 7). Sections about 330 m thick lie beneath Gooch and Rock Springs Table; however, these are much disturbed by landsliding (pl. 1).

Wendell (1970) divides the sedimentary rocks in Virgin Valley into two units, the Virgin Valley Formation (lower) and the Thousand Creek Formation (upper). As there is no clear lithologic distinction between them, these units are mapped as one in this report.

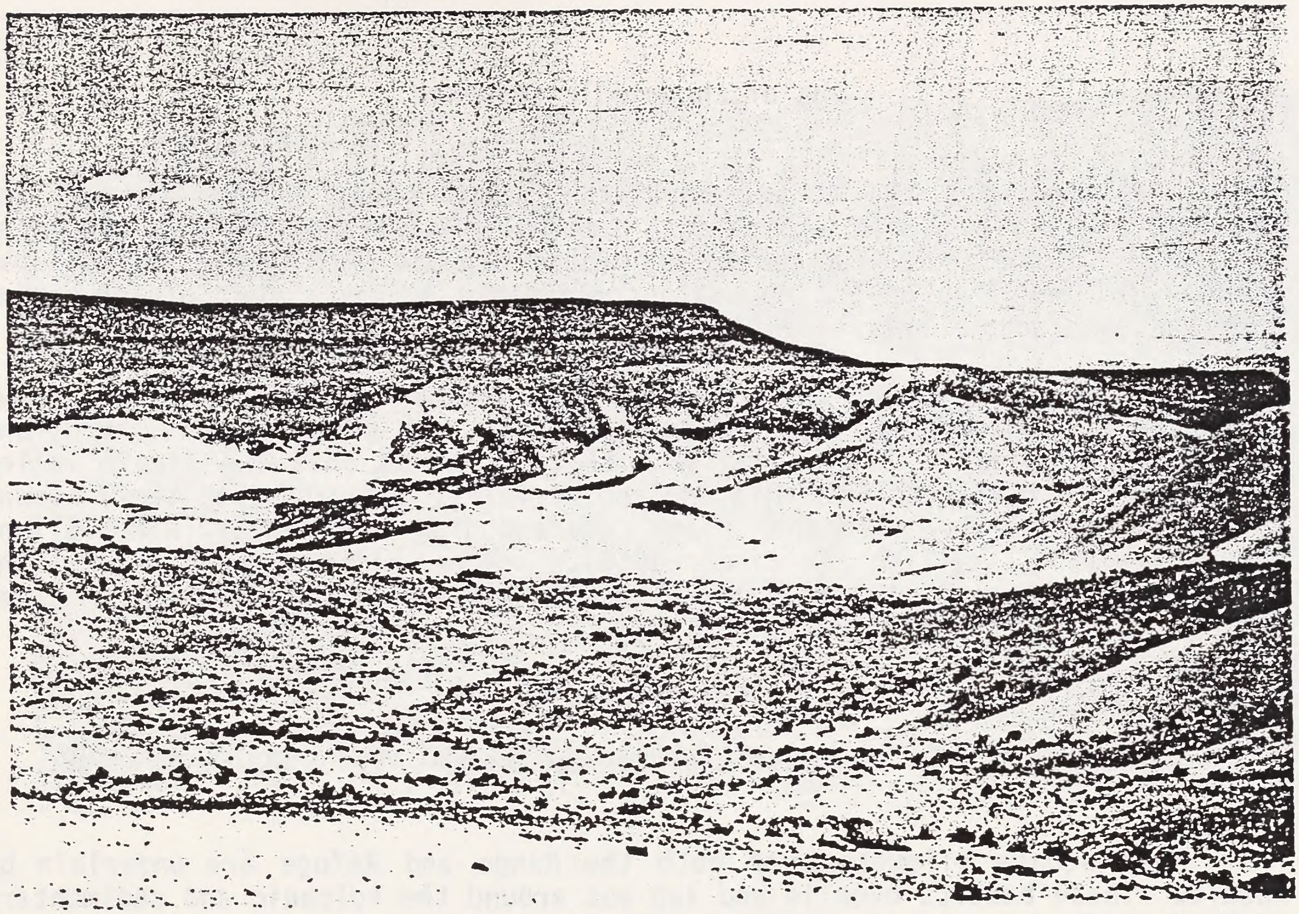

Figure 7. Bedded tuffaceous sedimentary rocks, about 1 km south of Thousand Creek Spring, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon. Badlands topography here contains many opal claims. Big Springs Table in background, basalt capping sedimentary rocks. Two levels shown separated by a normal fault.

Age of the middle sequence

K-Ar ages for the Canyon rhyolite, Summit Lake, Soldier Meadow, and Craine Creek tuffs (table 1) indicate a middle Miocene age for this sequence. The Idaho Canyon is considered to be middle Miocene also (Noble and others, 1970). The rhyolite of Nut Mountain conformably overlies the Soldier Meadow tuff and is probably only slightly younger.

Considerable fossil material has been recovered from the tuffaceous sedimentary rocks in the Virgin Valley-Thousand Creek area (Wendell, 1970, and references therein). These lead Wendell to conclude that the Virgin Valley Formation is middle and late Miocene and early Pliocene and that the Thousand Creek Formation is Pliocene (late Clarendonian and early Hemphillian) (Wendell, 1970, p. 66; Merriam, 1910). More recent usage places the Claredonian and early Hemphillian in the Miocene (Geologic Names Committee, U.S. Geological Survey, 1972).

Upper sequence

Basalt of Catnip Creek Tb

Many square kilometers of both the Range and Refuge are underlain by basalt. These basalts overlie and lap out around the volcanic and sedimentary rocks described previously. The basalt is thickest in the northwest part of the Range and north part of the Refuge (Catnip Creek, Rye Creek and vicinity) and the basalt consists of many thin flows. A type area has been assigned at Catnip Creek (secs. 3, 4, 9, and 10, T. 46 N., R. 22 E.); here the basalt is at least 30 m thick. A more accessible section is located at Racetrack Reservoir about 6 km to the southeast and consists of 24 flows in continuous vertical exposure in a fault scarp about 40 m high (fig. 8).

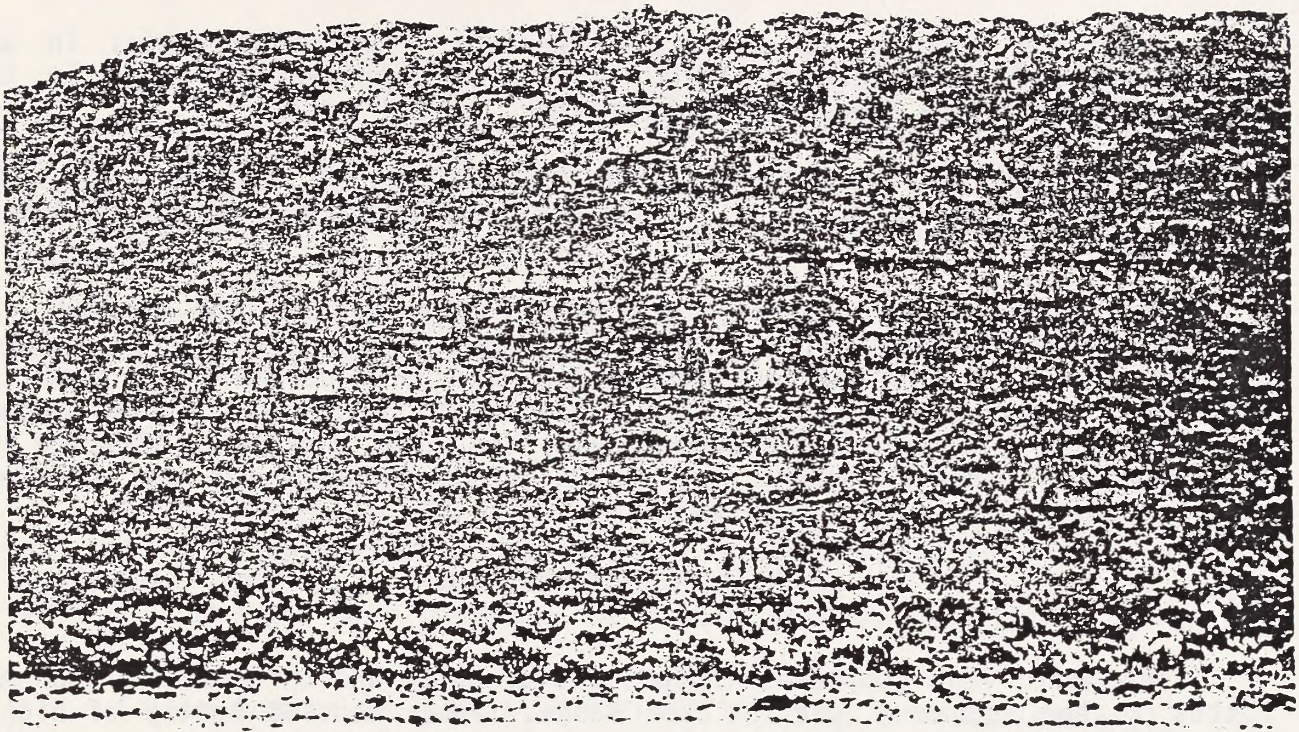

Figure 8.--Outstanding exposure of basalt flows at Racetrack Reservoir, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon. Total thickness of section about 40 m. Flows range from 0 to about 3 m thick, pinch and swell noticeably. About 24 flows in verticle alinement, average thickness 1.5 m.

From the section at Racetrack Reservoir the basalt thins in all directions and is interbedded with tuffaceous sedimentary rocks in the southwest part of the Range near Badger Creek.

In the east part of the area, the basalts cap Big Springs, Gooch, and Rock Springs Tables (figs. 6, 7). They are 3-8 m thick and consist of one or two flows.

The basalt is dark to medium gray and aphanitic to fine grained. It contains 25-60 percent plagioclase, 7-30 percent olivine, 12-50 percent clinopyroxene, and 2-12 percent magnetite, with 1-10 percent void space as openings between plagioclase grains (diktytaxitic texture). A few percent olivine and/or plagioclase microphenocrysts are locally present. Despite the wide range in mineral content, the range in SiO_2 content for most of these rocks is only from 47.9-49.1 percent.

Mafic vent complexes Tv

The mafic vent complexes include Bitner Butte and three smaller unnamed buttes in the southwest part of the Range. They consist mostly of highly vesicular basalt, in part of reddish color, and of both black and reddish cinders. Basalt of less vesicularity is locally intermixed. These buttes, the palagonite tuff rings (described below) and Mule Mountain, a low shield volcano near Bald Mountain Lake, form a northwest-trending chain that marks probable vent localities for the basalt of Catnip Creek.

Palagonite tuff Tpt

Three circular areas underlain by palagonite tuff have been mapped separately north and south of Badger Mountain. These are vent areas, where basaltic lava has been erupted into water, fragmented and altered piling up as cones or rings subsequently modified by erosion. The resulting tuff has medium to light olive gray matrix with dark gray scoria fragments. Both fragments and matrix are glass and clays. The tuff is weakly consolidated and friable but nevertheless tends to stand topographically above surrounding light-colored tuffaceous sedimentary rocks.

Basalt of Railroad Point Qb

Basalt caps Railroad Point, an elongate mesa in the northeast part of the Range, directly east of Big Springs Table. The basalt appears to have been an intercanyon flow but subsequent erosion of the surrounding sediments have inverted the topography producing a long capped ridge.

The basalt, a single flow about 5 m thick at the tip of Railroad Point, is dark gray and porous. It contains about 5 percent fresh olivine phenocrysts, which grade serially to groundmass olivine. Groundmass consists of about 45 percent plagioclase, 10 percent olivine, 15 percent clinopyroxene, and 5 percent magnetite with 20 percent void space. The distinctive groundmass clinopyroxene is of dark color, bladed form, and peppered with magnetite.

Basalt directly east of the north end of Rock Springs Table is tentatively correlated with the basalt of Railroad Point.

Age of the upper sequence

Two K-Ar dates on the basalt of Catnip Creek (table 1) average 9.4 m.y., an age that agrees well with the early Hemphillian age of fossils in conformably underlying strata (Wendell, 1970). The date of 1.2 m.y. on basalt from Big Springs Table reported by Walker and Swanson (1969) may not be correct.

A K-Ar date on the basalt of Railroad Point is 1.58±0.2 (table 1).

Surficial deposits

Surficial deposits in the Range and Refuge include alluvium and alluvial fans, playa deposits, and landslide deposits. These are indicated on the map only where thick and continuous enough to completely conceal underlying bedrock.

Alluvium is unconsolidated sand, gravel, and silt. Alluvial fans are similar, but commonly include coarser cobble, slab, and boulder material. Playa deposits are fine clay and silt with a small amount of evaporite minerals.

Landslide deposits are locally prominent, particularly on the north and south sides of Virgin Valley. These large masses of tuffaceous sedimentary rocks have slid and tilted from their original positions higher on the edges of Gooch and Rock Springs Tables, commonly carrying with them some of the basalt caprock. Many of the opal occurrences are in these landslide masses.

The most spectacular landslide in the area is that on the south side of Blowout Mountain. Here a mass of the rhyolite of Badger Mountain has broken loose, apparently catastrophically, and formed a separate hill below separated by a moat from the mountain. Vertical joints in the displaced mass suggest that it has rotated very little.

Structure

Faults

The geologic structure of the Range and Refuge is dominated by normal faults.

Near the southeast corner are a series of northeast-trending faults. These are on strike with the Craine Creek Valley, and in part take up the major displacement between Big and McGee Mountains and that valley.

Northwest-trending faults are predominant over most of the area. Areas near Fivemile Flat and on Badger Mountain have dominant northwest-trending faults with abundant cross faults, breaking the area into small blocks. To the north, the valley of Hell Creek is fault dominated, with most faults northwesterly and northerly to join others of similar trend near the Sage Hen Hills to the north.

Northwesterly trends are again dominant near the Oregon-Nevada state line in the Sage Hen Hills, parallel to those on Big Springs Table to the east, and to the major fault bounding McGee Mountain on the north.

In the west part of the area, north and south of Bald Mountain, northwest trends continue along strike with those on Badger Mountain. A crossing, northeast trend is also seen, and is probably related to adjustments at the end of north-trending Guano Valley.

The amount of faulting bears little apparent relationship to the age of the rocks. The basalt of Catnip Creek is locally faulted as much as the Idaho Canyon Tuff, the lowest unit in the middle sequence. Few faults were mapped (pl. 1) in the older andesites of Round Mountain and Bald Mountain, but more might be detected by detailed mapping. Faults in the basalt of Catnip Creek require that much faulting occurred after 9.4 m.y. B.P; lack of faulting on Railroad Point indicates little faulting on northwest trends since about 1.6 m.y. B.P.

Virgin Valley Basin

A downwarp centered at Virgin Valley produced a major basin of continental sedimentation in middle and late Miocene time. As much as 300 m of tuffaceous sedimentary rocks accumulated near its center. This basin, as expressed by its sedimentary content, extends as far south as Onion Lake, and as far west as Gooch Lake. It is less well defined on the north side, as sedimentary rocks at least a few hundred feet thick continue under Big Springs Table beyond the area mapped.

The main part of the basin is nearly surrounded by the Canyon rhyolite. This suggests that eruption of this unit may have contributed to the downwarp forming the basin through sinking of the land over a partially emptied magma chamber. This area is less faulted than its surroundings.

Depth to pre-Tertiary rocks

In the Pine Forest Range directly east of the valley of Craine Creek (eastern limit of mapped area) the Idaho Canyon tuff overlies 100-200 m of older basalt and welded tuff, which in turn overlie pre-Tertiary plutonic and metamorphic rocks (Smith, 1972). The top of pre-Tertiary rocks dips westward from these basement exposures and no older rocks crop out for 290 km. The intervening basin is underlain almost entirely by Miocene, Pliocene, and Quaternary rocks; none as old as Oligocene have been identified except near its margins.

The andesites of Round Mountain and of Bald Mountain are thick units (as much as 460 m) where fully developed, but both disappear along strike within a few miles in a north-south direction and therefore appear to be local volcanic piles of no great areal extent.

Given these facts, the depth to pre-Tertiary basement under the Range and Refuge is probably not great (see cross sections, pl. 1). A basement with an upper surface near 1,200 m above sea level seems most probable.

Calderas

Geophysical data, discussed in the geophysical section of this report, provides permissive evidence for the possible existence of calderas in the study area.

MINERAL RESOURCES OF THE CHARLES SHELDON WILDERNESS STUDY AREA, HUMBOLDT AND WASHOE COUNTIES, NEVADA, AND LAKE AND HARNEY COUNTIES, OREGON

INTERPRETATION OF AEROMAGNETIC AND GRAVITY DATA

By Donald Plouff, U.S. Geological Survey

Introduction

The aeromagnetic map shown on plate 2 is a part of more widespread surveys in adjacent areas of Nevada (U.S. Geological Survey, 1972a) and Oregon (U.S. Geological Survey, 1972b). Total intensity magnetic data were obtained along east-west lines flown at a spacing of about 3.2 km and at a nearly constant barometric elevation of 2743 m above sea level. The approximate effect of the earth's normal magnetic field has been removed from the observed total intensity data by subtracting a regional gradient of about 6 gammas per kilometer in the direction of magnetic north.

Gravity data at a total of 269 stations were collected by S. L. Robbins and K. D. Holden during September and October 1975 as part of the geologic assessment of the mineral resource potential of the study area. These data were supplemented by using data from the Department of Defense Gravity Library (written commun., 1975) at 123 previously established stations and by using data at 8 gravity stations in the Crump Geyser area, Oregon (Plouff, 1975). The procedures used to combine the three sets of data and to calculate values of terrain-corrected Bouguer anomalies are described in a report by Plouff, Robbins, and Holden (1976). The datum of observed gravity is that of Behrendt and Woollard (1961). Bouguer corrections to sea level and terrain corrections to a distance of 166.7 km are based on an assumed average rock density of 2.5 g/cm^3. The largest errors incorporated in the values of complete Bouguer anomalies contoured on the resultant Bouguer anomaly map (pl. 3) are attributed to errors approaching 1.5 milligals in the determination of terrain corrections. The average error in the determination of terrain corrections probably does not exceed 0.5 milligal and, hence, this source of error would have a negligible effect on changing the interpretation of the gravity map.

Continuing references to the geologic map (pl. 1) will be made in the following discussion of the geophysical data. Locations on the accompanying geophysical maps (pls. 2 and 3) are labeled in six categories: "C" for possible calderas, "F" for possible faults, "G" for gravity anomalies, "H" for hot springs, "M" for magnetic anomalies, and "T" for magnetic anomalies that are correlated with topography. Interpretation of some labeled geophysical anomalies that occur outside the study area will be discussed in order to facilitate interpretation of anomalies within the study area.

General features of the magnetic map

A prominent U-shaped regional magnetic maximum with its vertex near the center of the south edge of the map and extending northwestward and northeastward along magnetic ridges toward locations labeled M_1 and M_2 dominates the magnetic map (pl. 2). The magnetic ridges are separated by a broad minimum centered near M_3. The southwest edge of the U-shaped maximum is interrupted by a large magnetic minimum centered near location C_1. The interpretation of this closed minimum will be discussed in a later section. A prominent, north-south trending regional maximum along the east edge of the magnetic map is located outside the study area. This major magnetic high is spearated from the prominent U-shaped maximum in the study area by a broad minimum that follows the trend of Craine Valley.

Irregular-shaped local anomalies on the magnetic map generally are caused by variations of magnetization that typify rocks in volcanic terrane of the western United States. The most conspicuous area of relatively high magnetization occurs slightly north of the Range boundary at Hawks Mountain (labeled T_1 on plate 2). Here an 800-gamma magnetic maximum appears to be caused by domal masses and related flows of rhyodacitic to dacitic rock shown on the geologic map of Walker and Repenning (1965). The near coincidence of the 3,000-gamma magnetic contour line with the 1,830 m topographic contour line and the small southward offset of the innermost magnetic contour from the location of the topographic peak suggests that most of the anomaly is caused by the topographic effect of the volcanic rocks exposed at the surface. The 2,600-gamma, outermost closed contour, however, extends southward into the study area and indicates that magnetic rocks of this volcanic center extend beneath the Charles Sheldon Antelope Range. Therefore, based on the correlation between mineral deposits and volcanic centers observed in other areas of Nevada (Albers and Kleinhampl, 1970), this location may be a favorable target for mineral exploration.

The horizontal size of the double-peaked magnetic maximum in the northwest corner of the study area (labeled M_1) is similar to the broad maximum near Hawk Mountain, but the amplitude of about 400 gammas is smaller and the shape of the anomaly is not strongly controlled by the topographic expression of volcanic rocks exposed at the ground surface. The magnetization of volcanic rocks exposed at the surface beneath the northern magnetic peak evidently is low, because several flight lines cross a 250 to 300 m thick sequence of volcanic rocks along the escarpment (labeled T_9 and T_{10}) at the east edge of Guano Valley without discernible deflection of the observed magnetic field. A trachyandesite volcanic pile with a vent crops out at Antelope Butte (eastward of and between T_9 and T_{10}) in a one-kilometer circle shown on the map of Walker and Repenning (1965) and similar platy flows are exposed in the escarpment to the west. G. W. Walker (oral commun., 1978) mapped younger volcanic rocks that lap out against the trachyandesite and differentiate of a composite volcanic center with underlying magnetic differentiates. Therefore, the broad magnetic maximum centered near M_1 (pl. 2) indicates that rocks associated with this volcanic center extend beneath the northwest corner of the study area.

Less prominent magnetic maxima that reflect near surface rocks of moderately high magnetization occur over topographic maxima near the east edge of the magnetic map at locations labeled T_2 and T_3, at Big Mountain (T_4), and at Bartlett Peak near the southeast corner of the map (T_5). The broad minimum between locations T_6 and T_7 seems too large to simply reflect the effect of lower ground elevations along Craine Creek. The north-south sequence of broad magnetic minima also indicates the occurrence of a zone of rocks of low magnetization between the study area and a favorable zone of previous mineral exploration indicated by a series of mines and prospect pits along the east edge of the map. An inverse correlation between a magnetic minimum and a topographic maximum near the northeast corner of the map (T_8) may indicate reversed remanent magnetization of layers within Tertiary basalt and andesite flows shown on the geologic map of Walker and Repenning (1965). Though the location is outside the study area, this interpretation demonstrates the possibility that reversely magnetized volcanic rocks may underlie isolated magnetic minima within the study area.

General features of the gravity map

The Bouguer gravity anomaly map includes an irregular grouping of maxima and minima (pl. 3). No pronounced linear trends are present except at the east edge of the map outside the study area where a north-south trending regional maximum, labeled G_4-G_5, correlates with a similar magnetic ridge (T_2-T_3 on pl. 2). The maximum, labeled G_3, near the west edge of the gravity map is centered over rocks mapped as Tertiary andesite of Bald Mountain and the Tertiary rhyolite of Cottonwood Canyon. (See geologic map and cross section on plate 1.) These rocks are older and structurally uplifted relative to the surrounding rocks. The north and east edges of the gravity maximum inside the study area may be favorable sites to extend existing mercury exploration indicated by the occurrence of more than a dozen mining prospects to the south and west that are enclosed by the gravity maximum.

The locations of two closed anomalies on the gravity map seem to be correlated with outcrops of specific rock units shown on the geologic map. Closer examination, however, indicates that the anomalies reflect lateral changes within deeper, underlying rocks. The Idaho Canyon Tuff south of the Nevada-Oregon border probably is no less dense on the average than the surrounding geologic units and, hence, cannot account for the observed gravity minimum at G_2. The minus 175-mgal contour nearly outlines the northern part of an outcrop of Quaternary basalt near Rock Spring Table Reservoir (pl. 1), but the rock unit is too thin to explain the amplitude of the anomaly at G_1. An underlying structure that may cause the anomaly at C_1-C_2 will be discussed later.

Magnetic and gravity anomalies associated with faulting

Ore deposits are often located in and near fault zones, because they provide channels for transportation of ore-bearing solutions. Fault displacements often juxtapose rocks of contrasting physical properties at the same level on opposite sides of faults. Where faults are concealed by a cover of younger rocks, their locations can be revealed as fairly linear gravity or magnetic contours. Possible fault locations or concealed geologic boundaries and, hence areas that might be favorable for mineral exploration were identified either on the magnetic map (pl. 2) or on the gravity map (pl. 3) at locations labeled "F" and transferred to the same locations on the opposite map for comparison.

A steepened gradient between locations F_1 and F_2 on the magnetic map closely agrees with the location of a mapped fault with the downthrown side to the east. The magnetic map indicates the possibility of a largely concealed cross-fault that apparently indicates a shift of the main fault to a location near F_3 rather than along the fault near F_4. Though there is a contrast of magnetization between the rocks on each side of the fault, there is no similar contrast in density, because the gravity map does not indicate a similar north-south trend between locations F_1 and F_3. A gravity gradient between locations F_4 and F_5 agrees with the location of a mapped fault. The less dense rocks are located on the downthrown, northeast side of the fault. No similar contrast in intensities of magnetization of rocks on the two sides of the fault are indicated between locations F_4 and F_5. However, the trend of a saddle in the magnetic contours between F_8 and F_9 nearly parallels the northwest trend of a series of mapped faults to the northeast (pl. 1). This zone (F_8-F_9 on pl. 2) of relatively low magnetization separates the magnetic nose which enclosed the two small maxima to the southwest from the major magnetic anomaly centered at Hawk Mountain (T_1) to the north. The low magnetization in this magnetic saddle may be a result of rock alteration related to the circulation of fluids in an underlying, concealed fault zone.

Though differing in specific detail, both the gravity and the magnetic maps indicate similar gradients between locations labeled F_6 and F_7, with more dense and more highly magnetized rocks to the east. The width of both the gravity and magnetic maxima to the east are about 5 km and the location of the crestlines also agree. A north-south band of Mesozoic rocks (shown by Wilden, 1964; Walker and Repenning, 1965; and Smith, 1973), which forms an elongated structural and topographic maximum, nearly coincides with the crest, G_4-G_5, of the magnetic and gravity maxima. The decrease in level of the Bouguer gravity anomaly, between the location of the Mesozoic rocks and the younger rocks to the west in the study are is at least 15 mgals. If the observed change in gravity level wholly is an effect of a westward thickening of the Tertiary section of rocks and if it is assumed that the Mesozoic and older rocks have an average density of 2.65 g/cm^3 compared to 2.45 g/cm^3 for the younger rocks, for example, then the combined thickness of Tertiary rocks beneath the Charles Sheldon wilderness study area could exceed 1,800 m.

Gravity and magnetic anomalies related to hot springs

All five hot or warm springs in or adjacent to the Charles Sheldon wilderness study area occur near gravity maxima (labeled "H" on plate 3). Two localities occur within closed gravity highs (H_1 and H_2), one occurs along the edge of a closed gravity high (H_3), one occurs on gravity nose (H_4), and the last occurs on a gravity saddle (H_5) between lower gravity values to the northwest and southeast. There is no consistent relationship between magnetic anomalies (pl. 2) and the location of the hot or warm springs. One spring occurs within a closed magnetic maximum (H_4), one spring occurs near a closed magnetic minimum (H_3), two springs occur near relative magnetic highs (H_2 and H_5), and the last spring occurs near a relative magnetic low (H_1).

The occurrence of five hot springs near gravity maxima partly is a local densification effect of induration caused by precipitation and cementation within tuffaceous sedimentary rocks, which elsewhere are porous and of lower density. The occurrence of opal deposits and petrified wood in Virgin Valley near location H_1 exemplifies the process of induration, that results in a local increase of density relative to the surrounding sedimentary rocks. The gravity anomalies, however, appear to be too broad in horizontal dimensions to be explained wholly as a result of a local increase of density due to induration of sedimentary rocks.

A correlation between gravity maxima and intrusive centers has been reported near the San Juan Mountains volcanic field in Colorado (Plouff and Pakiser, 1972). Assuming that hot springs near the Charles Sheldon wilderness study area are underlain by intrusive centers, as indicated by local gravity maxima, also could define an underlying geothermal source that heats the hot water. But no intrusive rocks are exposed at the surface nor is there doming near any of the hot springs. The postulated intrusive rocks would have to be younger than the youngest igneous rocks age-dated at the surface (table 1)--1.6 m.y. for the basalt of Railroad Point and greater than 8 m.y. for the other dated rocks--to have retained their heat without replenishment from radioactive sources or an underlying magma chamber. Therefore the possible correlation between hot springs and intrusive centers near the study area remains speculative.

An alternate explanation for the apparent correlation between gravity maxima and the localization of hot springs might be that the gravity maxima outline uplifted fault blocks. The concept of correlation with fault blocks is consistent with prevalent explanations for the origin of hot springs in northern Nevada that involve a cycle of descending meteoric water, heating at depth, and rising to the surface with deep circulation via crushed rock along Basin and Range faults (for example, Hose and Taylor, 1974). Three of the gravity maxima (H_2, H_3, and H_4) are located along a fault zone or lineament suggested by Hose and Taylor (1974, p. 13). There are no mapped faults (pl. 1) that specifically correspond to the outlines of the gravity maxima, however, and consequently, the possible correlation between fault blocks and the localization of hot springs remains speculative.

The gravity maximum, H_2, occurs along the gravity ridge, G_4-G_5, which, as discussed in the last section, probably is an effect of Mesozoic rocks that are structurally elevated and more dense than the surrounding Tertiary rocks. The four other gravity maxima that are near hot springs and the closed gravity maximum, labeled G_6, near Onion Lake similarly might indicate the underlying presence of uplifted pre-Tertiary rocks or pre-Tertiary rocks that are more dense than the surrounding basement rocks.

As discussed above, the gravity maxima near hot springs could be caused by any combination of densified sediments, buried intrusive rocks or plutons, uplifted fault blocks, and pre-Tertiary basement highs. These possible anomalous conditions warrant further studies of the localities H_1, $H_3(F_2)$, and H_5 as potential sites for geothermal and mineral deposits in the study area. Though no hot springs are shown near Onion Lake in the southeast corner of the study area, the adjacent gravity and corresponding magnetic maxima (labeled G_6) similarly indicate the location of an area that warrants further study.

Gravity and magnetic anomalies related to possible calderas

Four closed minima on the gravity map (C_1, C_2, C_3, and G_2 on pl. 3) are located within or along the border of the study area. Closed gravity minima in other parts of Nevada commonly are elongated parallel to Basin and Range faults and indicate anomalous thicknesses of alluvium or tuffacous sediments underlying Basin and Range valleys. The gravity minima in the study area, however, do not overlie alluvial valleys nor do any of the anomalies seem to be correlated with mapped geologic units (pl. 1).

The most extensive gravity minimum, labeled C_1, closely conforms in size and shape to a magnetic minimum (pl. 2). A curved line, consisting of diamond-shaped symbols, drawn near the approximate average position of the center of the steepest gradients along the edges of the magnetic and gravity minima (pls. 2 and 3) shows how closely the two types of geophysical anomalies agree in shape and size. Not that the equivalent ground positions used for the magnetic cotours were displaced 0.4 km northeastward to adjust for the effect of the 66-degree inclination of the earth's field at an average flight altitude of 0.9 km. The direction of elongation of the 17 by 25 km oval-shaped boundary is to the northwest.

The area outlined near C_1 is underlain by a large mass of rock that has a lower density and a lower magnetization than the surrounding rocks. A two-dimensional analysis of the gravity anomaly, using Bott's (1960) iterative method along section A-A' (pls. 2, 3, and 4), provides an estimate of a possible subsurface mass configuration that fits the observed gravity anomaly. Using a constant density contrast of 0.2 g/cm^3, which for 8 iterations and a 2 km spacing of calculated points, gives a better fit along the edges of the model than other assumed contrasts, yields a saucer-like mass of low-density rocks that extends from the surface to a depth of 2.7 km. Further refinement of the model using three-dimensional methods was not attempted, because the derived two-dimensional model (pl. 4) is relatively thin compared to its width, and consequently, an insignificant increase of depth estimates using three-dimensional methods would be obtained.

Assuming a nominal magnetic susceptibility contrast of 0.002 emu/cm^3 between the interior and exterior rocks, the magnetic effect of the gravity model was calculated. The agreement with the observed magnetic anomaly, however, is imperfect due to the combination of the interfering effect of rocks of higher magnetization located to the southwest, possible contrasts of the magnetization of rocks within the model, and the approximation of absorbing the effect of three-dimensional anomalies into a two-dimensional model.

More than half of the rocks enclosed by the elliptical-shaped line centered at C_1 are mapped as tuffaceous sedimentary rocks (pl. 1). Most of the remaining rocks are mapped as the rhyolite of Badger Mountain. Substantial amounts of Soldier Meadow Tuff and the basalt of Catnip Creek are also present. The less dense rocks within the gravity model mostly could consist of a thickened sequence of tuffaceous sedimentary rocks. An assumed average density contrast of 0.2 g/cm^3 between the sedimentary rocks within the depression and the surrounding Tertiary volcanic rocks is reasonable, although the average density contrast could range from 0.1 to 0.5 g/cm^3 depending on the degree of inter-bedding, compaction of the sediments, the character of the concealed volcanic rock, and other complexities.

A saucerlike depression filled with tuffaceous sedimentary rocks indicates collapse associated with a previously unmapped caldera, which formed in response to the explosive release of large volumes of ash-flow tuffs during rapid depletion of an underlying, local magma chamber. Both G. W. Walker (oral commun., 1976) and Norman MacLeod (oral commun., 1976) suspected that calderas are present in this area of northwest Nevada, to account for the observed distribution of ashflow tuffs and associated rhyolite. At present, however, there essentially is no surface geologic evidence to outline the boundary of the postulated caldera that is identified by the geophysical anomalies. In retrospect, only a rather linear topographic low along the southwest rim of the caldera and a set of northwest-trending faults (pl. 1) parallel to the direction of elongation of the caldera may be related to the earlier formation of a caldera. Possibly the occurrence of the spectacular landslide on the southwest side of Blowout Mountain (see Geologic Chapter) indicates a late response triggered by an increment of gradual basinward tilting of the landsurface following compaction of the underlying tuffaceous sedimentary rocks or secondary slump of the caldera wall.

The 6 by 8 km closed gravity minimum centered at Rock Spring Table Reservoir (C_2) also may depict an underlying caldera. The shape of the corresponding magnetic minimum (pl. 2), however, is distorted by the effect of a superimposed dipole low related to the prominent magnetic maximum, G_1-T_4-G_6, to the southeast. The nearly 15-mgal amplitude of the gravity minimum indicates that the underlying rocks of relatively low density are about the same total thickness as the low-density rocks beneath Badger Mountain. Again, there appears to be no geologic evidence to suggest the presence of an underlying caldera. Most of the surface rocks near C_2 consist of a thin cap of the basalt of Catnip Creek (pl. 1), which would have been deposited after the active cycles associated with the postulated caldera ceased. In retrospect, the occurrences of a faulted one-kilometer diameter outcrop of rhyolite of Badger Mountain within the oval-shaped boundary, tuffaceous sedimentary rock along most of the edges, and huge landslides to the north and northeast may be related to the formation of a caldera.

A concealed caldera also may underlie the closed gravity low, C_3, near Idaho Canyon in the southeast corner of the study area. Small gravity and magnetic minima west of the study area between locations labeled G_7 and G_8, separated from the main caldera at C_1 by maxima that strike northeast through location G_9, may indicate the presence of a fault-controlled, thick wedge of tuffaceous sedimentary rocks beneath the surficial basalts. A magnetic minimum centered near G_{10} indicates the location of a possible connection between the main caldera and the minima near G_7 and G_8, but there are no gravity stations to substantiate this relation. The smaller magnetic minima also could be caused by underlying rocks with reversed remanent magnetization or, possibly, may be caused by locally altered rocks that are enclosed by rocks with higher magnetization.

If calderas underlie the Charles Sheldon wilderness study area, faulting associated with collapse might provide channels for warm, ore-bearing solutions to migrate upward toward the surface. Furthermore, the apparent low level of magnetization of rocks within the postulated caldera at C_1 suggests destruction of former magnetization by rock alteration that could be associated with mineralization.

Calderas are believed to play an important role in the localization of ore deposits (Albers and Kleinhampl, 1970; and Steven and others, 1974). The McDermitt caldera, located about 100 km northeast of the Charles Sheldon wilderness study area, for example, is the site of the largest operating mercury mine in North America (Rytuba, 1976; and McKee, 1976). Five mercury mines are adjacent to ring fracture faults and a uranium mine and other uranium occurrences are located within rhyolite domes related to the McDermitt caldera (Rytuba, 1976).

The gravity anomaly associated with the McDermitt caldera (Plouff, 1976; and Rytuba, 1976, fig. 3) is more complex than the symmetrically shaped gravity minima in the wilderness study area. The overall appearance of the anomaly at the McDermitt caldera is a 30 by 40 km horseshoe-shaped gravity maximum that opens to the north with superimposed gravity minima inside the north, northeast, and south rims, that reflect thickened tuffaceous sedimentary rocks. Intense, elongated gravity minima that are caused by thick alluvial fill in bordering Basin and Range faulted valleys reduce the effect of the gravity minimum. The gravity minimum is further reduced because the process associated with resurgent doming probably has introduced more dense rocks into the McDermitt caldera and has uplifted the area so that previously overlying, less dense, rocks have been removed by erosion.

The postulated calderas in the Charles Sheldon wilderness study area, however, more nearly would resemble the erosional stage of the Silent Canyon caldera, Nye County, Nevada, for example, which "is almost completely obscurred by younger unrelated rocks from other nearby centers" (Noble and others, 1968). The shape of that caldera was revealed by a combination of detailed geologic studies, drill-hole data, and a 18 by 24 km, 15 mgal gravity minimum (Orkild and others, 1968, fig. 2).

Geochemical data collected in the Charles Sheldon wilderness study area, as reported in the following chapter, generally show high concentrations of mercury roughly in the same location as the postulated calderas. But additional geologic studies are needed to verify that the gravity and magnetic minima outline concealed calderas, which could have high mineral potential. Until further studies are made, alternative interpretations to explain the cause of the geophysical minima cannot be discounted. For example, the minima also might reveal underlying plutons with lower densities and magnetizations than the surrounding crystalline basement rock. It is unlikely, however, that the plutons could extend upward into the section of Tertiary volcanic rocks, because the average density of the plutons probably would exceed that of the surrounding Tertiary rocks. The combination of a mass excess in the Tertiary section and a mass deficiency within the pre-Tertiary basement, however, would tend to result in a more complicated gravity anomaly pattern than indicated by the observed gravity anomalies.

MINERAL RESOURCES OF THE CHARLES SHELDON WILDERNESS STUDY AREA, HUMBOLDT AND WASHOE COUNTIES, NEVADA, AND LAKE AND HARNEY COUNTIES, OREGON

GEOCHEMICAL EVALUATION OF THE MINERAL RESOURCE POTENTIAL AND THE GEOTHERMAL RESOURCES

By J. B. Cathrall, D. F. Siems, G. L. Crenshaw, and E. F. Cooley

U.S. Geological Survey

Introduction

Evaluation of the mineral resource potential and geothermal potential of the Charles Sheldon wilderness study area is based on the interpretation of (1) analyses of rock and stream-sediment samples, (2) analyses of spring water samples, and one algae sample collected from a thermal spring, (3) geologic mapping, and (4) geophysical (aeromagnetic and gravity) surveys. This section discusses the interpretations of geochemical results (items 1 and 2 above), which are evaluated in context with the results from the geological and geophysical studies. The results indicate that the area has low potential for the discovery of exposed mineral deposits; however, the results suggest that the area may contain concealed deposits.

Methods of evaluation

Evaluation of the mineral resource potential of the Charles Sheldon wilderness study area must be made on the bases of speculative information in view of the problems caused by the blanket cover of volcanic rock. The geochemical association of many elements and the structural and geophysical features found here can only be interpreted in the light of their association with each other.

For a geochemical evaluation, a total of 884 stream-sediment samples were collected along the larger streams and near the confluence of small tributaries (Cathrall and others, 1977). Stream-sediment samples collected from dry stream channels consisted of several scoops of fine sediments. The sediments were taken across the width of the main channel. Stream-sediment samples from flowing streams were collected from midchannel, and where this was impractical, the sediment was collected at the side of the stream channel. The dry weights of samples ranged from 150 to 250 grams (g).

Samples were placed in metal-free cloth bags or paper envelopes; wet samples were air dried, and all samples were prepared by shaking through an 80-mesh [0.18 millimeter (mm)] stainless steel sieve. The minus -80 mesh fraction was saved for analyses.

In addition to stream sediments, 396 rock samples collected from 314 localities were taken and analyzed (Cathrall and others, 1977). Rock samples were collected from bedrock but a few, particularly along escarpments, were taken from float (loose rock chips) shed from the escarpment. Representative samples of all types and varieties of rocks present in the study area were taken. Few, if any, showed visible indications of alteration or mineralization, although this type of rock was sought. Samples weighed from 0.25 to 0.5 kilogram (kg); all were crushed in a jaw crusher to approximately 6 mm, split through a Jones splitter, and half of the split was pulverized to less than 250 mesh for analyses. The remaining half is stored at the U.S. Geological Survey laboratories in Denver, Colo.

The procedures used in analyzing rock and stream-sediment samples were identical. Semiquantitative spectrographic methods were used for Fe, Mg, Ca, Ti, Mn, Ag, B, Ba, Be, Co, Cr, Cu, La, Mo, Nb, Ni, Pb, Sc, Sn, Sr, V, W, Y, and Zr (Grimes and Marranzino, 1968). Atomic absorption spectrophotometry was used to determine Cd, Au, Zn (Ward and others, 1963, 1969) and Sb (Welsch and Chao, 1976). Mercury was determined by a flameless atomic absorption spectrophotometry method described by Vaughn and McCarthy (1964). Arsenic was determined by colorimetry (Ward and others, 1963). Neutron activation, delayed neutron counting, was used for U and Th (Millard, 1976).

The analytical results for stream-sediment and rock samples were evaluated to determine background and anomalous values in apparently unmineralized rock. Anomalous values may be related to mineral deposits. The lower limit of concentration of an element to be considered anomalous is called the threshold value and was determined by plotting the cumulative frequency of values on logarithmic paper similar to the methods described by Sinclair (1974), Lepeltier (1969) and Parslow (1974). The plot defines two populations (groups of values) represented by straight lines. The intersection of these lines defines the threshold value. Figure 9, an illustration of the cumulative frequency plot for mercury, is included as an example.

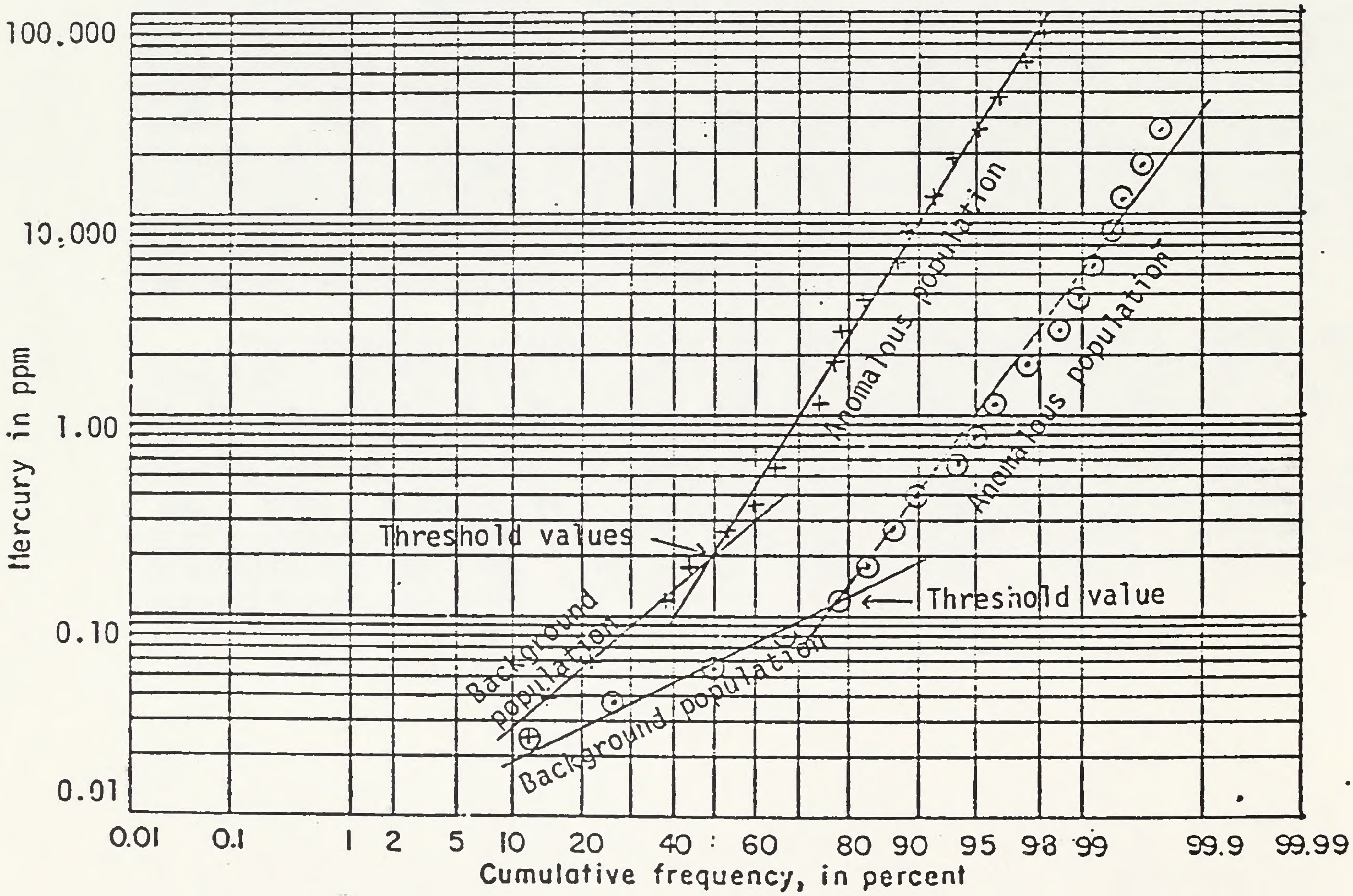

Figure 9—Cumulative frequency plot of mercury for 396 rock samples (+) and 384 stream-sediment samples (⊙), Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

The cumulative frequency plots of those elements and ratio of elements that showed definite threshold values will be discussed in the following section of this report. Threshold values, crustal abundance, the range of values, the number of values, the percentile distribution, and the geometric means of these elements and the cadmium to zinc ratio are listed in table 2. The samples containing highly anomalous values of these elements, and anomalous Cd/Zn ratios were used to construct distribution maps (figs. 12-20, 23).

The low level concentration of those elements listed on table 3, when compared with their crustal abundance, suggests that the area has a very low potential for the discovery of exposed mineral deposits.

Concealed potential mineral resources

Several elements including gold, mercury, antimony, arsenic, tungsten, molybdenum, manganese, barium, and the cadmium to zinc ratio are present in anomalous amounts in the Charles Sheldon wilderness study area. These elements and their association with one another suggests the possible presence of concealed mineral deposits.

Studies of hydrothermal deposits have shown zoned groups of elements are concentrated more or less radially from the source of mineralizing fluids outward. In the Refuge area, the zonal arrangement of elements formed by the anomalous values of Ba, Hg, Mn, As, Sb, W, and Mo parallels the sequence of metal zonation first presented by Emmons (1936). The distribution of these elements, when viewed in relation to a reconstructed vein system model (table 4), indicates the uppermost arrangements of metals. As would be expected, no single example contains all of the mineral groups given in the model. Discrepancies--irregularities, reversals, and poorly defined zoning--between the observed and the model vein system may occur. These discrepancies may be caused by overlapping of deposits from two or more magmatic centers, by retreat or advance of magmatic centers during one period of deposition, by repeated periods of mineralization in a single area, by supergene enrichment, and by other causes not fully understood.

Table 2.—Threshold values, crustal abundance, range of values, number of values, percentile distributions, and geometric means of rock samples and stream-sediment samples for selected elements and for the cadmium to zinc ratio, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

[Values for Hg, Sb, As, W, Mo, Ba, and Mn are expressed in parts per million (ppm). Cd:Zn values are expressed as a ratio. Lower limits of detection in ppm: Hg=0.02, Sb=0.5, As=10, W=50, Mo=5, Ba=20, Mn=10, Cd=0.4, Zn=0.6. n=396 for rocks and 884 for stream sediments. Analytical methods: Mn, Ba, Mo, and W by emission spectroscopy; Hg by flameless atomic absorption; Sb, Cd, and Zn by atomic absorption; As by colorimetry. Analysts: E. F. Cooley, G. L. Crenshaw, and D. F. Siems. Leaders (—), indicate insufficient data]

Element or element ratio	Sample media	Threshold value	Mean crustal abundance	Range of detectable values	Number of detectable values	Selected percentiles based on number (n) of samples				Ge me
						25th	50th	75th	90th	
Mercury	Rock	0.2	0.06[1]	0.02- >100	358	0.1	0.2	1.4	11	
	Stream-sediment	.15	--	.02- >100	884	.04	.05	.11	.37	
Antimony	Rock	10	1[2]	.5 - 800	234	--	1	4	22	
	Stream-sediment	10	--	.5 - 60	170	--	--	--	1.1	
Arsenic	Rock	80	5[2]	10 - 1400	372	10	21	40	86	
	Stream-sediment	80	--	10 - 200	861	11	21	26	41	
Tungsten	Rock	<50[3]	1[2]	<50[3] - 500	21	--	--	--	--	
	Stream-sediment	<50[3]	--	<50[3] - 50	2	--	--	--	--	
Molybdenum	Rock	7	2.3[2]	5 - 500	60	--	--	--	9	
	Stream-sediment	7	--	5 - 20	74	--	--	--	--	
Barium	Rock	1500	430[2]	20 ->5000	387	120	410	1,040	1,840	3
	Stream-sediment	1500	--	100 - 2000	884	460	620	770	1,030	6
Manganese	Rock	2000	1000[2]	20 ->5000	389	150	350	790	1,490	3
	Stream-sediment	2000	--	20 - 5000	884	760	990	1,260	1,640	9
Cadmium to Zinc ratio	Rock	.02	--	.002- .077	396	.01	.013	.018	.021	
	Stream-sediment	.02	.002[2]	.002- 1.91	882	.02	.04	.1	.025	

[1] Green (1959)

[2] Goldschmidt (1954)

[3] Less than value shown, but line observed by spectrographer

TABLE 3.--*Statistical summary of the analytical results for stream-sediment and rock samples as compared to the crustal abundance for the average igneous rock, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake County, Oregon.*

[Values for Fe, Mg, Ca, and Ti reported in percent; all other values reported in ppm (parts per million). Lower limits of detection for semiquantitative emission spectrographic analyses: Fe and Ca = 0.05; Mg = 0.02; Ti = 0.002; Mn, Au, B, Bi, Cr, Pb, Sn, V, Y, and Zr = 10; Ag = 0.5; As and Zn = 200; Ba, Cd, La, and Nb = 20; Be = 1; Co, Cu, Mo, Ni, and Sc = 5; Sb and Sr = 100; W = 50. Upper limits of detection for semiquantitative emission spectrographic analyses: Ti = 1; Mg = 10; Fe and Ca = 20; Cd and Au = 500; Be, Bi, La, Sn, and Zr = 1,000; B, Co, Mo, Nb, and Y = 2,000; Mn, Ag, Ba, Cr, Sr, and Ni = 5,000; As, Sb, W, V, and Zn = 10,000; and Cu and Pb = 20,000. Lower limits of detection for all other methods of analysis: Au = 0.05; Zn = 5; Cd = 0.4; Sb = 1; Hg = 0.02; As = 10; W = 20. Upper limit of detection for Hg = 100. Uncensored population is one in which the element concentrations fall within the sensitivity limits of the method used. Censored population is one in which element concentrations are coded with N, L, or G: N, not detected at limit of detection; L, detected but below limit of detection; G, greater than upper limit of detection. n, total number of samples analyzed for the particular element presented. This number is determined by adding columns headed N, L, G, and Number of values. Leaders (--), no data or insufficient data. Analysts: E. F. Cooley, G. L. Crenshaw, R. J. Knight, H. L. Millard, Jr., and D. F. Siems.]

Element	Sample type	Crustal abundance[1]	Data based on the censored population			Data based on the uncensored population				Percentile distribution in ppm based on n samples analyzed			
			N	L	G	Number of values	Range of values	Geometric mean	Geometric deviation	25th	50th	75th	90th
Semiquantitative emission spectrography[2]													
Fe	Rock	5	0	6	0	390	0.02 - 20	1.5	3.9	0.7	2.0	4.1	5.5
	Stream-sediment	--	0	0	1	883	.5 - 20	4.4	1.5	3.3	4.3	5.3	7.1
Mg	Rock	2.9	0	24	0	372	.02 - 3	0.2	3.2	.1	.1	.4	.8
	Stream-sediment	--	0	0	0	884	.15 - 2	.9	1.5	.7	.9	1.1	1.4
Ca	Rock	3.6	0	11	0	385	.05 - 10	.3	3.1	.1	.2	.5	1.0
	Stream sediment	--	0	0	0	884	.05 - 5	1.0	1.5	.8	1.0	1.3	1.9
Ti	Rock	.44	0	1	1	394	.005- 1	.15	3.7	.1	.2	.4	.7
	Stream sediment	--	0	0	29	855	.1 - 1	.5	1.7	.4	.5	.8	1.1
Mn	Rock	1000	3	4	7	382	20 -5,000	319	3.2	147	350	792	1,492
	Stream sediment	--	0	0	0	884	150 -5,000	976	1.6	759	992	1,259	1,639
Ag	Rock	0.02	394	0	0	2	1 - 3	--	--	--	--	--	--
	Stream sediment	--	880	1	0	3	.7 - 1	--	--	--	--	--	--

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[1] Goldschmidt (1954).

[2] Grimes and Marranzino (1968).

TABLE 3.--*Statistical summary of the analytical results for stream-sediment and rock samples as compared to the crustal abundance for the average igneous rock, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake County, Oregon.* --Continued

Element	Sample type	Crustal abundance[1/]	Data based on the censored population			Data based on the uncensored population				Percentile distribution in ppm based on n samples analyzed			
			N	L	G	Number of values	Range of values	Geometric mean	Geometric deviation	25th	50th	75th	90th
Semiquantitative emission spectrography[2/]--Continued													
As	Rock	5	389	0	0	7	300 - 1,000	--	--	--	--	--	--
	Stream-sediment	--	884	0	0	0	--	--	--	--	--	--	--
B	Rock	10	1	107	0	288	10 - 150	21	2	--	13	26	44
	Stream-sediment	--	1	7	0	876	10 - 100	25	1.5	20	24	33	44
Ba	Rock	430	0	9	2	385	20 - 5,000	369	3.5	117	405	1,041	1,840
	Stream-sediment	--	0	0	0	884	100 - 2,000	622	1.5	463	617	774	1,029
Be	Rock	6	2	23	0	371	1 - 50	2.6	2.1	1.5	2.2	3.4	6.5
	Stream-sediment	--	4	26	0	854	1 - 7	1.7	1.4	1.3	1.9	2.3	2.6
Bi	Rock	.2	395	0	0	1	10 -	--	--	--	--	--	--
	Stream-sediment	--	884	0	0	0	--	--	--	--	--	--	--
Co	Rock	40	79	226	0	91	5 - 100	10.4	2.0	--	--	--	10
	Stream-sediment	--	1	9	0	874	5 - 70	15.7	1.7	11	18	23	29
Cr	Rock	200	54	244	0	98	10 - 200	17	1.8	--	--	--	20
	Stream-sediment	--	0	3	0	881	10 - 200	41	1.7	31	44	53	71
Cu	Rock	70	1	131	0	264	5 - 200	9	1.8	--	5.1	11	18
	Stream-sediment	--	0	0	0	884	5 - 50	21	1.5	18	23	30	35
La	Rock	18.3	3	68	0	325	20 - 200	63	1.5	40	51	73	102
	Stream-sediment	--	3	3	0	878	20 - 200	55	1.4	43	50	62	79

[1/] Goldschmidt (1954).
[2/] Grimes and Marranzino (1968).

3. tist summ of the analytical results for stream-sediment and rock samples as compared to the crustal abundance for the average igneous rock, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake County, Oregon. --Continued

Element	Sample type	Crustal abundance[1/]	Data based on the censored population			Data based on the uncensored population				Percentile distribution in ppm based on n samples analyzed			
			N	L	G	Number of values	Range of values	Geometric mean	Geometric deviation	25th	50th	75th	90th
						Semiquantitative emission spectrography[2/]--Continued							
Mo	Rock	2.3	300	36	0	60	5-500	16	3.3	--	--	--	9.2
	Stream-sediment	--	723	87	0	74	5 20	8	1.5	--	--	--	--
Nb	Rock	20	7	382	0	7	20-50	--	--	--	--	--	--
	Stream-sediment	--	24	814	0	46	10-50	21	1.6	--	--	--	--
Ni	Rock	100	4	292	0	100	5-200	9	2.2	--	--	4	8
	Stream-sediment	--	0	12	0	892	5-100	19	1.7	14	21	26	37
Pb	Rock	16	39	48	0	309	10-100	20	1.6	9	19	24	33
	Stream-sediment	--	1	3	0	880	10-70	22	1.4	20	23	30	37
Sb	Rock	1	349	10	0	37	100-1,000	215	1.9	--	--	--	--
	Stream-sediment	--	880	2	0	2	100-200	--	--	--	--	--	--
Sc	Rock	5	44	84	0	268	5-100	10	1.9	--	6	17	23
	Stream-sediment	--	1	1	0	882	5-30	15	1.4	13	17	21	24
Sn	Rock	40	373	7	0	16	10-70	14	1.8	--	--	--	--
	Stream-sediment	--	866	15	0	3	10-100	--	--	--	--	--	--
Sr	Rock	150	39	162	1	194	100-1,500	232	1.9	--	--	249	413
	Stream-sediment	--	1	1	0	882	100-1,000	360	1.5	286	372	467	533
V	Rock	150	0	23	0	373	10-500	38	2.4	19	35	65	111
	Stream-sediment	--	0	0	0	884	20-1,000	102	1.5	83	101	127	184
W	Rock	1	375	7	0	14	50-500	81	1.9	--	--	--	--
	Stream-sediment	--	882	1	0	1	50-	--	--	--	--	--	--

1/ Goldschmidt (1954).
2/ Grimes and Marranzino (1968).

TABLE 3.--*Statistical summary of the analytical results for stream-sediment and rock samples as compared to the crustal abundance for the average igneous rock, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake County, Oregon.* --Continued

Element	Sample type	Crustal abundance[1]	Data based on the censored population			Data based on the uncensored population				Percentile distribution in ppm based on n samples analyzed			
			N	L	G	Number of values	Range of values	Geometric mean	Geometric deviation	25th	50th	75th	90th
Semiquantitative emission spectrography[2] --Continued													
Y	Rock	28.1	3	43	0	350	10 - 300	43	1.9	23	41	56	89
	Stream-sediment	--	0	1	0	883	10 - 200	47	1.5	28	38	48	55
Zn	Rock	80	354	21	0	21	200 - 1,000	--	--	--	--	--	--
	Stream-sediment	--	861	13	0	10	200 - 500	--	--	--	--	--	--
Zr	Rock	220	0	15	9	372	10 - 1,000	202	2.4	178	251	342	490
	Stream-sediment	--	0	0	5	879	50 - 1,000	248	1.5	204	259	330	382
Atomic Absorption													
[3]Au	Rock	0.001	283	101	0	4	0.06- 0.84	--	--	--	--	--	--
	Stream	--	152	0	0	0	-- --	--	--	--	--	--	--
[3]Zn	Rock	80	0	2	0	394	.6 - 190	13	3.2	7	15	28	57
	Stream-sediment	--	0	0	0	884	9.8 - 216	30	1.4	23	30	37	49
[3]Cd	Rock	.18	22	147	0	227	.4 - 6.8	1.1	1.9	--	.5	1.2	2.0
	Stream-sediment	--	28	273	0	581	.4 - 2	.5	1.3	--	.4	.5	.7
[4]Sb	Rock	1	42	120	0	234	1 - 800	4	4.7	--	1.0	3.6	22
	Stream-sediment	--	309	404	0	170	.5 - 60	2	2.7	--	--	--	1
[5]Hg	Rock	[6] .06	11	27	8	350	.02- 82	.44	7.3	.1	.2	1.4	10
	Stream-sediment	--	18	21	1	844	.02- 38.5	.08	3.2	.04	.05	.11	.37

[1] Goldschmidt (1954).
[2] Grimes and Marranzino (1968).
[3] Ward and others (1963).
[4] Welsch and Chao (1976).
[5] Vaughn and McCarthy (1965).
[6] Green (1959).

TABLE 3.--*Statistical summary of the analytical results for stream-sediment and rock samples as compared to the crustal abundance for the average igneous rock, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake County, Oregon.* --Continued

Element	Sample type	Crustal abundance[1]	Data based on the censored population			Data based on the uncensored population				Percentile distribution in ppm based on n samples analyzed			
			N	L	G	Number of values	Range of values	Geometric mean	Geometric deviation	25th	50th	75th	90th
						Colorimetry							
[3]As	Rock	5	0	24	0	372	10 - 1,400	24	2.4	10	21	40	86
	Stream-sediment	--	14	9	0	861	10 200	19	1.7	11	21	26	41
[3]W	Rock	1	192	199	0	5	-- --	--	--	--	--	--	--
	Stream-sediment	--	--	--	--	--	-- --	--	--	--	--	--	--
						Neutron Activation[7]							
U	Rock	4	0	0	0	90	0.36 - 860	12	4.6	4	8	35	133
	Stream-sediment	--	0	0	0	44	2.6 - 13	5	1.4	3	5	6	7
Th	Rock	11.5	0	0	0	60	3 - 25	17	2.3	10	17	24	56
	Stream-sediment	--	0	0	0	42	5 - 32	13	1.4	9	13	17	22

[1] Goldschmidt (1954).

[3] Ward and others (1963).

[7] Millard (1976).

Table 4.--A reconstructed vein system, from the surface downward[1]

1. Barren zone. Chalcedony, quartz, barite, fluorite, etc. Some of the veins carry a little mercury, antimony, or arsenic.
2. Mercury. Cinnabar deposits, commonly with chalcedony, marcasite, etc. Barite-fluorite veins.
3. Antimony. Stibnite deposits, often passing downward into galena with antimonates. Some carry gold.
4. Gold-Silver. Bonanza gold deposits and gold-silver deposits. Argentite with arsenic and antimony minerals common. Tellurides and selenides at places. Relatively small amounts of galena, sphalerite, and chalcopyrite are present; gangue includes quartz, adularia, alunite, with calcite, rhodochrosite, and other carbonates.
5. Barren. Most nearly consistent barren zone; represents the bottoms of many Tertiary precious-metal veins. Quartz, carbonates, etc., with small amounts of pyrite, chalcopyrite, sphalerite, and galena.
6. Silver. Argentite veins, complex silver minerals with antimony and arsenic, stibnite, some arsenopyrite, etc.; quartz gangue, at places with siderite.
7. Lead. Galena veins, generally with silver; sphalerite generally present, increasing with depth; some chalcopyrite. Gangue of quartz with carbonates.
8. Zinc. Sphalerite deposits; galena and some chalcopyrite generally present. Gangue is quartz and in some deposits carbonates of calcium, iron, and manganese.
9. Copper. Tetrahedrite, commonly argentiferous; chalcopyrite present. Some pass downward into chalcopyrite. Enargite veins, generally with tetrahedrite.
10. Copper. Chalcopyrite veins, most with pyrite, many with pyrrhotite. The gangue is quartz and at some places carbonates and feldspar. Orthoclase and sodic plagioclase not rare, but high-calcium plagioclase very rare; generally carry precious metals. Uranium, probably main horizon of uraninite.
11. Gold. Deposits with pyrite, commonly arsenopyrite. Quartz, carbonates, and some with feldspar gangue. Some with tourmaline. Tellurides not uncommon and at places abundant. At places zones 10 and 11 are reversed.
12. Arsenic. Arsenopyrite with chalcopyrite, etc.
13. Bismuth. Bismuthinite deposits. Native bismuth, quartz, pyrite, etc.
14. Tungsten. Veins with tungsten minerals, arsenopyrite, pyrrhotite, pyrite, chalcopyrite. Tungsten occurs in higher zones in large amounts, but this is the main horizon.
15. Tin. Cassiterite veins with quartz, tourmaline, topaz, feldspar, etc.
16. Barren. Quartz, feldspar, pyrite, carbonates, and small amounts of other minerals.

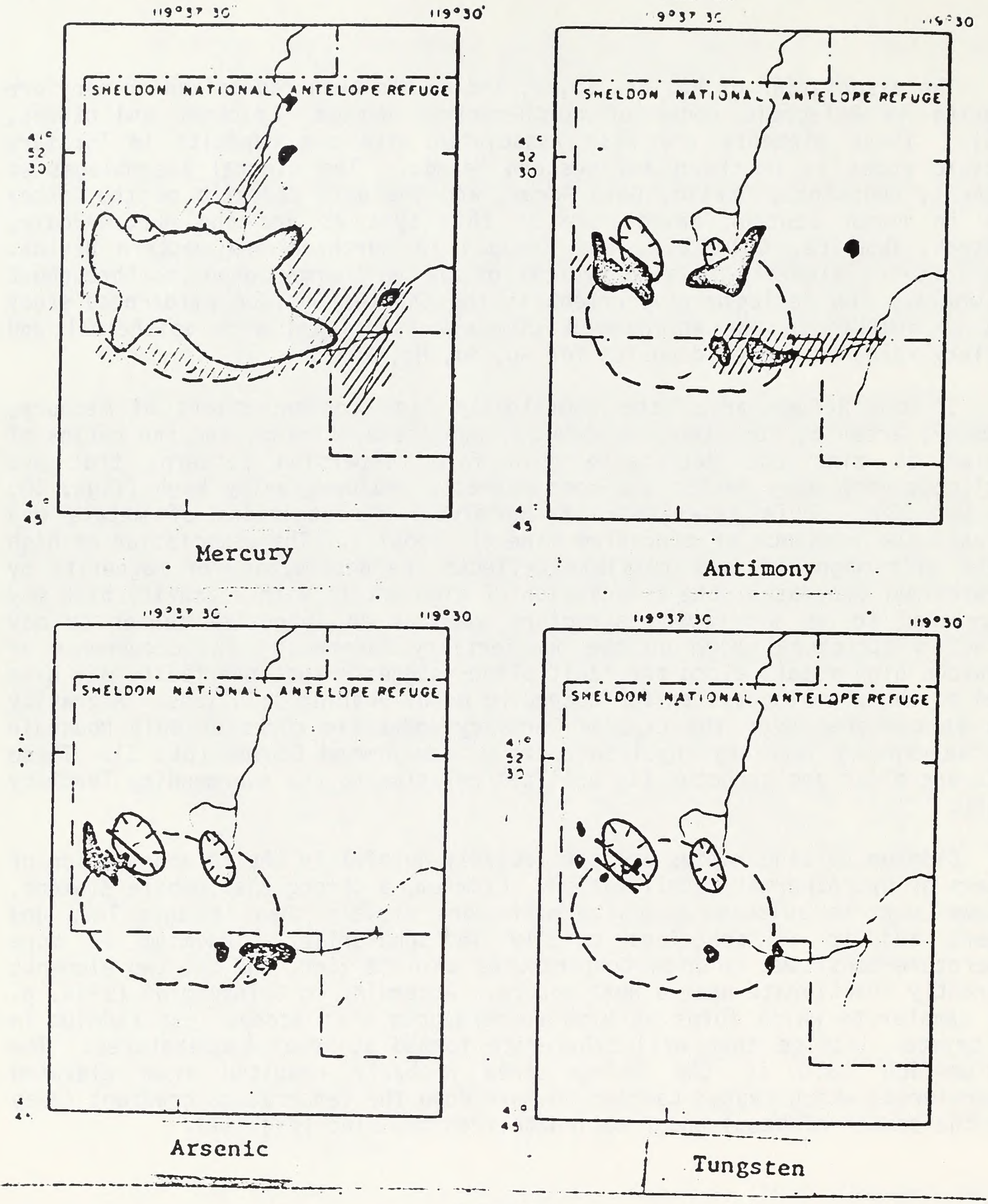
---

[1] Emmons, 1936

The association of Hg, As, Sb, W, and Au has been recognized in many ore deposits in Paleozoic rocks of north-central Nevada (Erickson and others, 1966). These elements are also associated with ore deposits in Tertiary volcanic rocks in northern and western Nevada. The mineral assemblages at Getchell, Bootstrap, Carlin, Gold Acres, and the gold deposits of the Cortez area in north central Nevada are of this type as are the Aurora-Bodie, Comstock, Opalite, Goldfield, and Tonopah in northern and western Nevada. This suite of elements is also typical of the epithermal deposits throughout the world. The geologic environment in the Charles Sheldon wilderness study area is similar to the environment commonly associated with epithermal and Tertiary volcanic center deposits for Au, Ag, Hg, and Sb.

In the Refuge area, the anomalously high concentrations of mercury, antimony, arsenic, tungsten, molybdenum, manganese, barium, and the ratios of cadmium to zinc and detectable gold form dispersion patterns that are contiguous with many faults and some magnetic and/or gravity high (figs. 10, 11, and 23). This assemblage of anomalous concentrations of metals may indicate the presence of concealed mineral deposits. The association of high metals with magnetic lows possibly reflects the destruction of magnetite by hydrothermal processes; the association of high metals with a gravity high may be related to an underlying structure such as an intrusive center or may reflect a structural high on the pre-Tertiary basement. The occurrence of anomalous high metals along the fault planes suggests that the faults may have acted as the plumbing system for ascending metal-bearing solutions. A gravity high is centered over the exposed Tertiary andesitic rocks of Bald Mountain and the exposed Tertiary rhyolite rocks of Cottonwood Canyon (pl. 1). These rocks are older and structurally uplifted relative to the surrounding Tertiary basalt.

Cadmium to zinc ratios are particularly helpful in the interpretation of centers of hydrothermal metallization. Cadmium, a strong chalcophile element, follows zinc in sulphide deposits much more closely than it does lead and copper, and it is contained chiefly in sphalerite. Cadmium is more temperature-sensitive to high temperatures than is zinc, and the two elements apparently fractionate near a heat source. According to Goldschmidt (1954, p. 271) sphalerite which forms at high temperatures will accept less cadmium in its crystal lattice than will sphalerite formed at lower temperatures. The cadmium-rich halo in the Refuge area probably resulted from elevated temperatures, which caused cadmium to move down the temperature gradient (away from the center of heat) and fractionate from the zinc (fig. 11).


119°37'30"
119°30'
SHELDON NATIONAL ANTELOPE REFUGE
41°52'30"
41°45'
Mercury
Antimony
Arsenic
Tungsten

EXPLANATION

Area where rock samples contain anomalous concentrations

Area where stream-sediment samples contain anomalous concentrations

Ranges of anomalous concentrations:

	Rock samples	Stream-sediment samples
Hg	0.2 ->100 ppm	0.2 ->100 ppm
Sb	10-1400 ppm	10- 60 ppm
As	80- 800 ppm	80- 100 ppm
W	<50- 100 ppm	--

Closed gravity high

Magnetic low

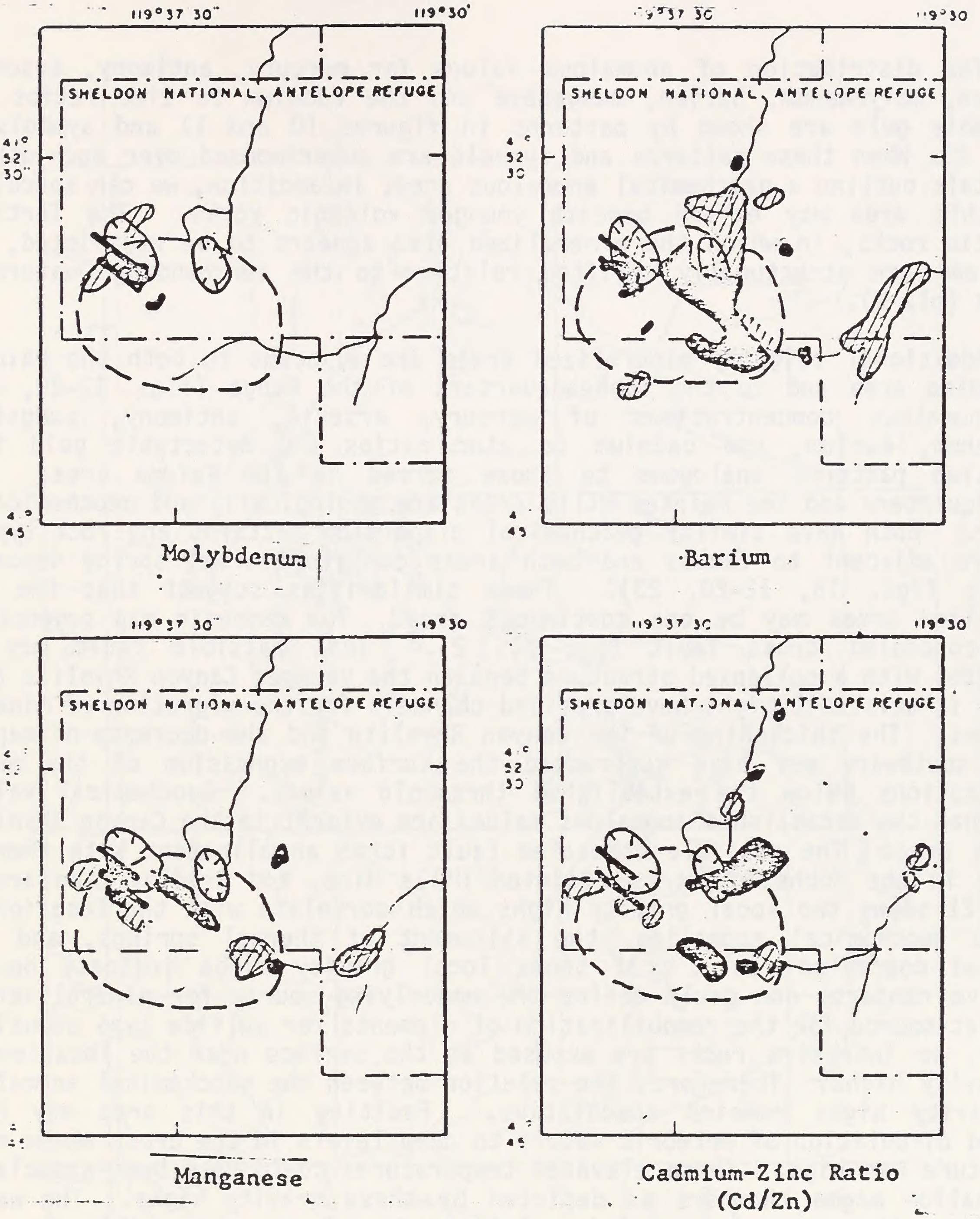
Fault

Method of analyses: Hg by flameless atomic absorbtion; As by colorimetry; W by emission spectroscopy; and Sb by atomic absorption.

Analysts: E. L. Cooley, G. L. Crenshaw, and D. F. Siems

0 1 2 3 Miles
0 1 2 3 4 5 Kilometers

Figure 10.--Relationship between selected magnetic lows, faults, a gravity high, and anomalous concentrations of mercury, antimony, arsenic, and tungsten in rock samples and stream-sediment samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.



119°37'30"
119°30'
41°52'30"
41°45'
SHELDON NATIONAL ANTELOPE REFUGE
Molybdenum
Barium
Manganese
Cadmium-Zinc Ratio (Cd/Zn)

EXPLANATION

▩ Area where rock samples contain anomalous concentrations or anomalous ratios

▨ Area where stream-sediment samples contain anomalous concencentrations

Range of anomalous concentrations and anomalous ratios:

	Rock samples	Stream-sediment samples
Mo	7- 100 ppm	10- 15 ppm
Ba	1500->5000 ppm	1500-2000 ppm
Mn	2000->5000 ppm	2000-5000 ppm
Cd:Zn	0.05- 1.9 ppm	-- --

◌ Closed gravity high

Magnetic low

Fault

Method of analyses: Mo, Ba, and Mn by emission spectroscopy; Cd and Zn by atomic absorption.

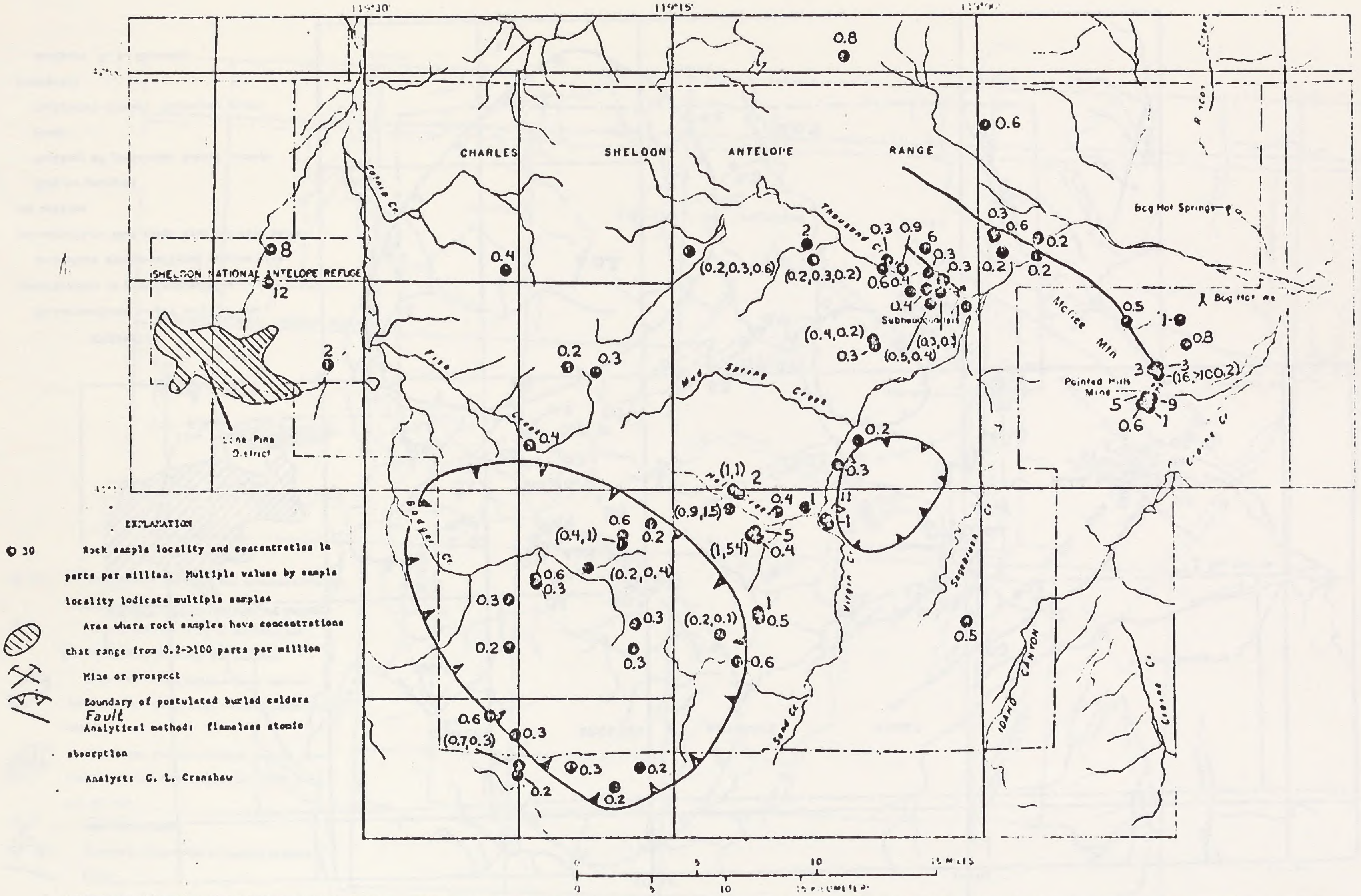
Analysts: E. L. Cooley, G. L. Crenshaw, and D. F. Siems

0 1 2 3 Miles
0 1 2 3 4 5 Kilometers

Figure 11. Relationship between selected aeromagnetic lows, faults, a gravity high, and anomalous concentrations of molybdenum, barium, manganese and anomalous cadmium to zinc ratios ≥ 0.05 in rock samples and stream-sediment samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, and Lake and Harney Counties, Oregon.

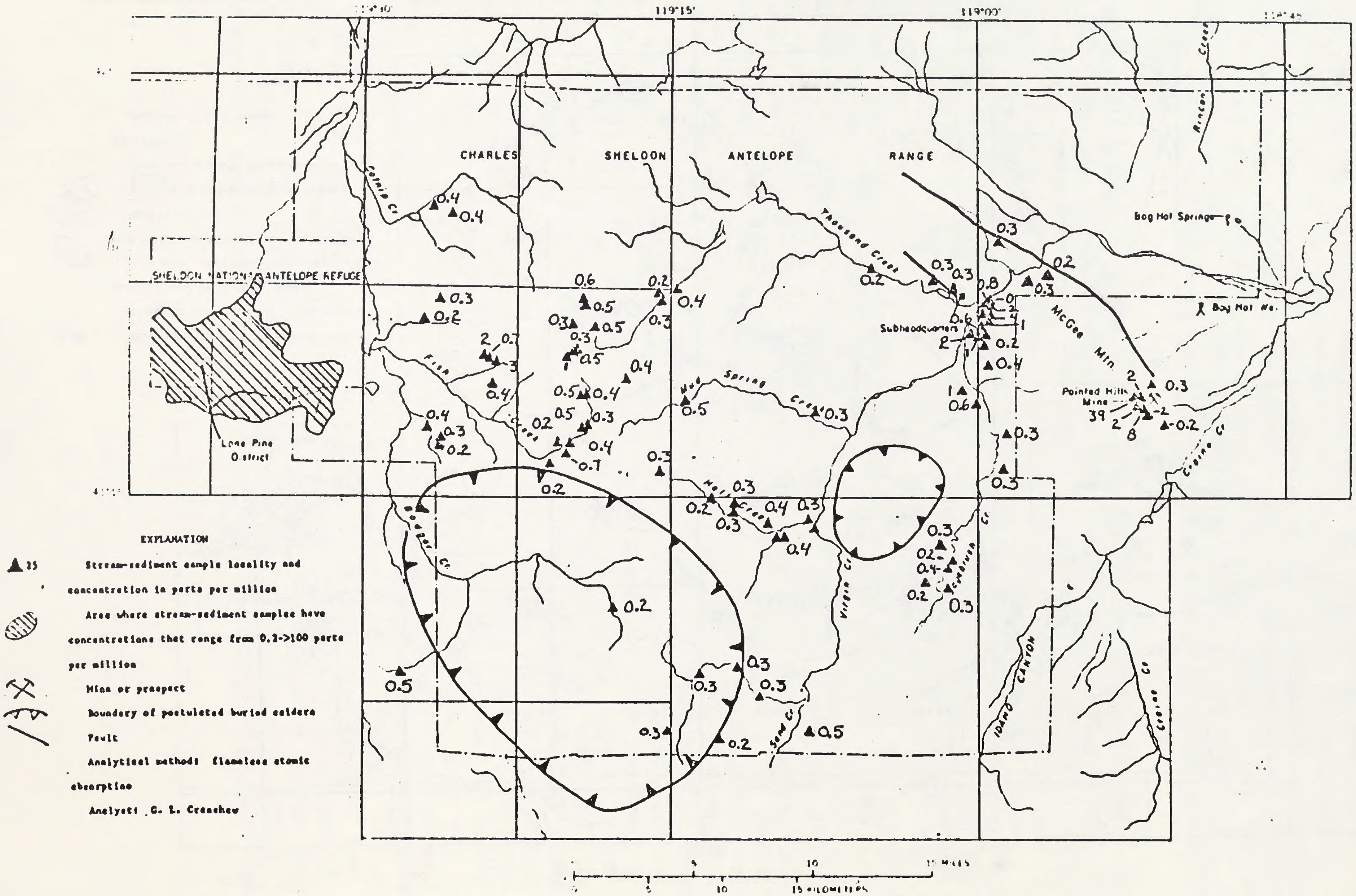
The distribution of anomalous values for mercury, antimony, arsenic, tungsten, molybdenum, barium, manganese and the cadmium to zinc ratios and detectable gold are shown by patterns in figures 10 and 11 and symbols in figure 23. When these patterns and symbols are superimposed over each other, the metals outline a geochemical anomalous area; in addition, we can speculate that this area may extend beneath younger volcanic rocks. The Tertiary andesitic rocks, in which the mineralized area appears to be restricted, are older and are structurally uplifted relative to the surrounding Quaternary basalts (pl. 1).

Additional slightly mineralized areas are adjacent to both the Painted Hills mine area and to the Subheadquarters of the Range (figs. 12-20, 23). The anomalous concentrations of mercury, arsenic, antimony, tungsten, molybdenum, barium, and cadmium to zinc ratios and detectable gold form dispersion patterns analogous to those formed in the Refuge area. The Subheadquarters and the Painted Hills areas are geologically and geochemically similar. Both have similar geochemical dispersion patterns and rock types, both are adjacent to faults and both areas contain thermal spring deposits (pl. 1; figs. 1B, 12-20, 23). These similarities suggest that the two mineralized areas may be one continuous area. The magnetic map suggests a large concealed cross fault (F_3, pl. 2). This possible fault may be associated with a collapsed structure beneath the younger Canyon Rhyolite (pl. 1). If it exists it might have provided channels for the migration of mineral solutions. The thickening of the Canyon Rhyolite and the decrease of mapped faults southward may have suppressed the surface expression of the metal concentrations below the established threshold values. Geochemical values lower than the established anomalous values are evident in the Canyon Rhyolite in this area. The possible concealed fault forms an alinement with thermal springs in the Subheadquarters, Painted Hills Mine, and Gridley Lake areas. Figure 21 shows two local gravity highs which correlate with the location of the two geochemical anomalies, the alinement of thermal springs, and the suggested concealed fault. If these local gravity highs indicate buried intrusive centers, one could define the underlying source for mineralization or a heat source for the remobilization of elements for sulfide type deposits; however, no intrusive rocks are exposed at the surface near the location of the gravity highs. Therefore, the relation between the geochemical anomalies and gravity highs remains speculative. Faulting in this area may have promoted circulation of meteoric waters to deep levels in the crust where rock temperature was high. These elevated temperatures could have been associated with shallow magma chambers as depicted by these gravity highs. The water could have then ascended as hot solutions that were responsible for the formation of the anomalous values in this area. North and northwest of the Subheadquarters, the mineralized area appears to terminate where younger basalts overlie the tuffaceous sedimentary or concealed host rocks; this mineralized area may extend northwestward beneath the younger basalt of Catnip Creek.



119°30'
119°15'
119°00'
CHARLES
SHELDON
ANTELOPE
RANGE
SHELDON NATIONAL ANTELOPE REFUGE
Lone Pine District
Big Hot Springs
McGee Mtn
Painted Hills Mine
Subhoa Knolls
Thousand Cr
Mud Spring Creek
Virgin Cr
Badger Cr
Colony Cr
Fish Creek
Sagebrush
Sand Cr
IDAHO CANYON
Cottonwood Cr
0 5 10 15 MILES
0 5 10 15 KILOMETERS
EXPLANATION
30 Rock sample locality and concentration in parts per million. Multiple values by sample locality indicate multiple samples
Area where rock samples have concentrations that range from 0.2->100 parts per million
Mine or prospect
Boundary of postulated buried caldera
Fault
Analytical method: flameless atomic absorption
Analyst: C. L. Cranshaw

Figure 12.--Distribution of anomalous concentrations of mercury in rock samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon



119°30'
119°15'
119°00'
118°45'
CHARLES
SHELDON
ANTELOPE
RANGE
SHELDON NATIONAL ANTELOPE REFUGE
Lone Pine District
Thousand Creek
Subheadquarters
McGee Mtn.
Painted Hills Mine
Bog Hot Springs
Bog Hot Mine
Rincon Creek
Spring Creek
Virgin Cr.
Idaho Canyon
Colman Cr.
EXPLANATION
Stream-sediment sample locality and concentration in parts per million
Area where stream-sediment samples have concentrations that range from 0.2->100 parts per million
Mine or prospect
Boundary of postulated buried caldera
Fault
Analytical method: flameless atomic absorption
Analyst: G. L. Crenshaw
0 5 10 15 MILES
0 5 10 15 KILOMETERS

Figure 13.--Distribution of anomalous concentrations of mercury in stream-sediment samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon

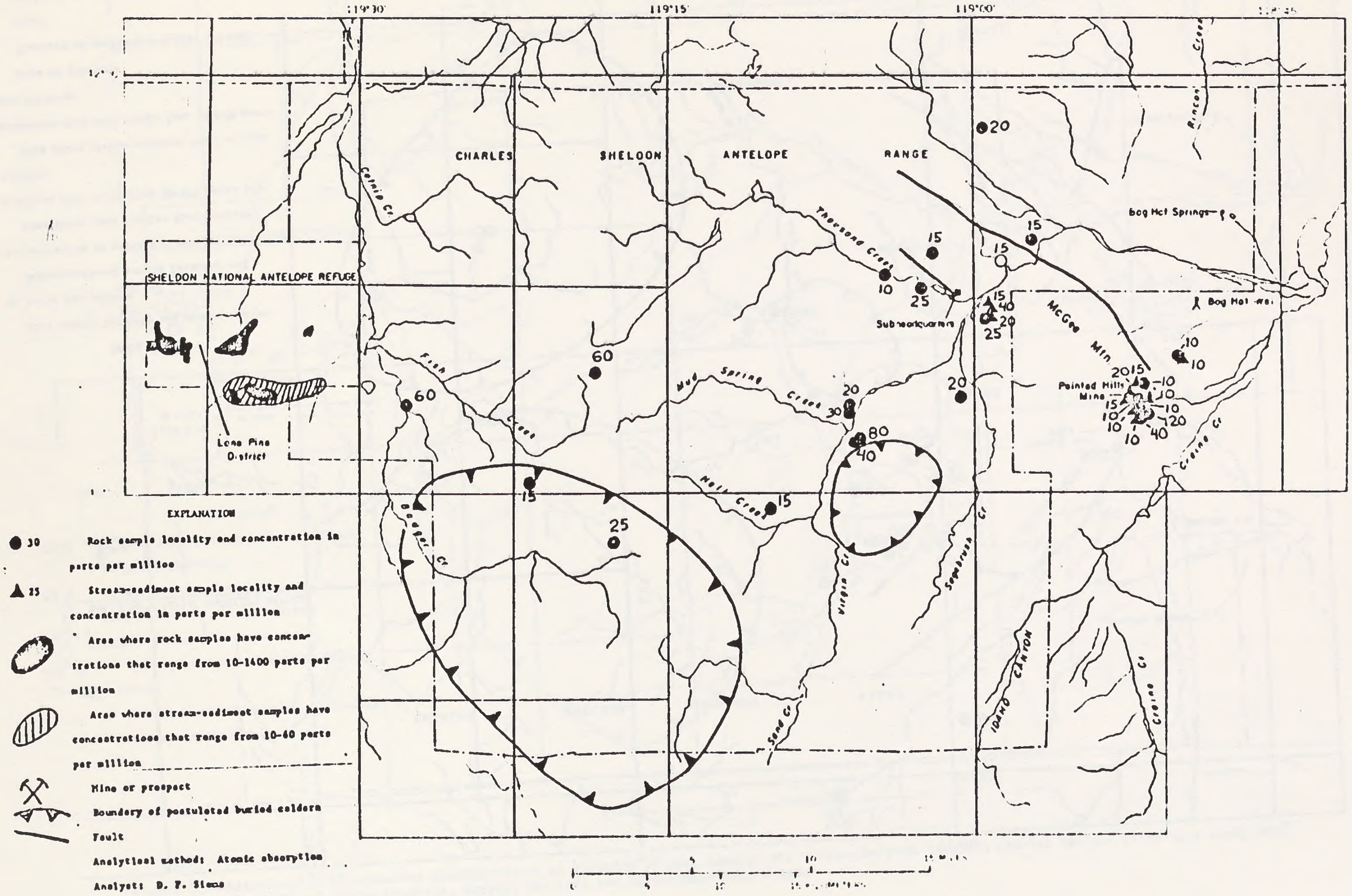
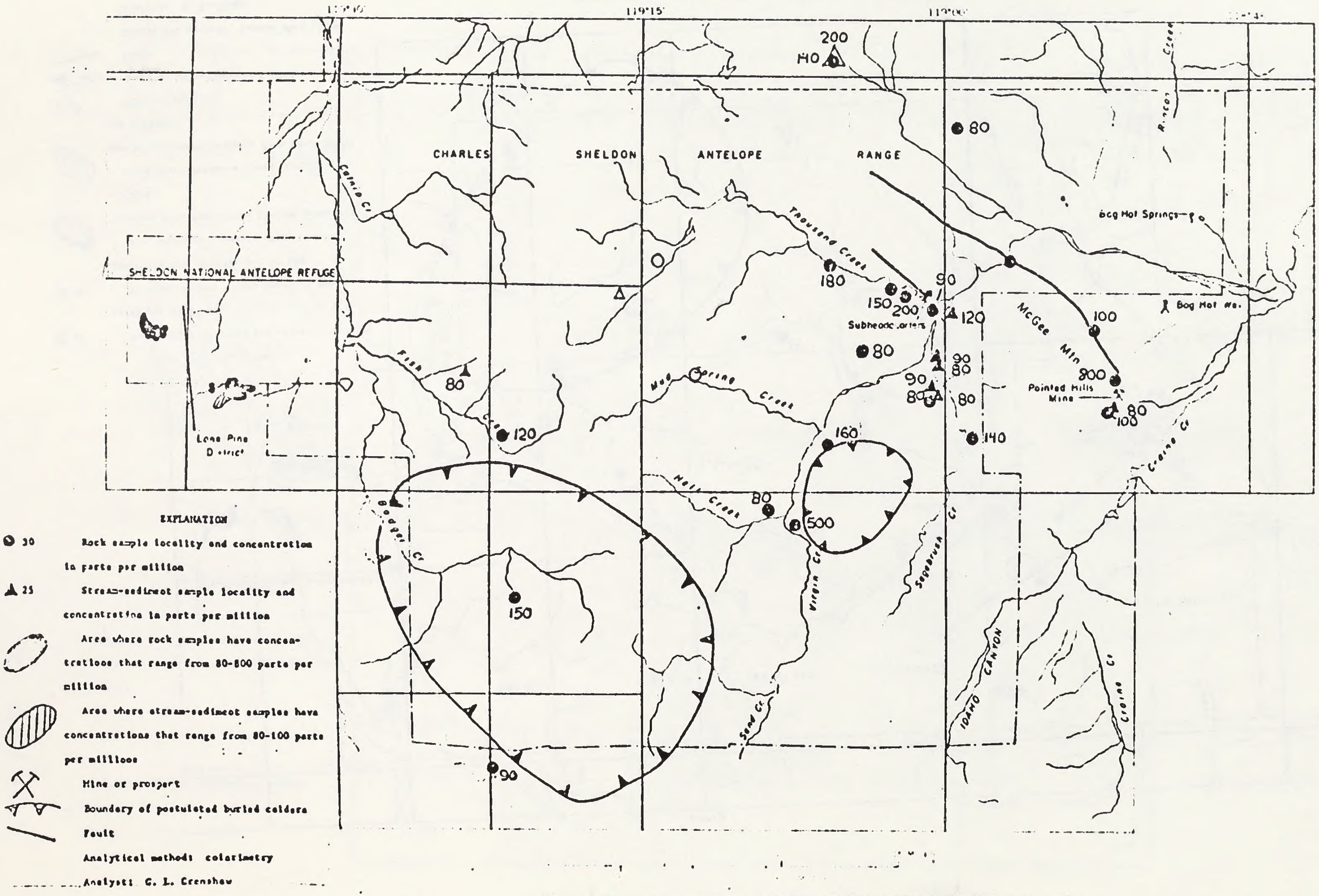

119°30'
119°15'
119°00'
CHARLES SHELDON ANTELOPE RANGE
SHELDON NATIONAL ANTELOPE REFUGE
Lone Pine District
Colman Cr
Fish Creek
Badger Cr
Mud Spring Creek
Thousand Creek
Hell Creek
Virgin Cr
Sagebrush Cr
Sand Cr
IDAHO CANYON
Craine Cr
Rincon Creek
Bog Hot Springs
Bog Hot well
Subheadquarters
McGee Mtn
Painted Hills Mine
EXPLANATION
30 Rock sample locality and concentration in parts per million
25 Stream-sediment sample locality and concentration in parts per million
Area where rock samples have concentrations that range from 10-1400 parts per million
Area where stream-sediment samples have concentrations that range from 10-60 parts per million
Mine or prospect
Boundary of postulated buried caldera
Fault
Analytical method: Atomic absorption
Analyst: D. F. Siems
5
10
15 MILES
15 KILOMETERS

Figure 14.--Distribution of anomalous concentrations of antimony in rock samples and stream-sediment samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon



119°30'
119°15'
119°00'
118°45'
CHARLES
SHELDON
ANTELOPE
RANGE
SHELDON NATIONAL ANTELOPE REFUGE
Lone Pine District
Catnip Cr
Fish Cr
Thousand Creek
Mud Spring Creek
Hell Creek
Badger Cr
Virgin Cr
Sand Cr
Sagebrush Cr
IDAHO CANYON
Craine Cr
Rincon Creek
Bog Hot Springs
Bog Hot Ws.
McGee Mtn
Pointed Hills Mine
Subheadquarters
200
140
80
180
150
200
90
120
100
800
80
108
90
80
90
80
80
140
160
500
80
120
80
150
90
EXPLANATION
Rock sample locality and concentration in parts per million
Stream-sediment sample locality and concentration in parts per million
Area where rock samples have concentrations that range from 80-800 parts per million
Area where stream-sediment samples have concentrations that range from 80-100 parts per million
Mine or prospect
Boundary of postulated buried caldera
Fault
Analytical method: colorimetry
Analyst: G. L. Crenshaw

Figure 15.--Distribution of anomalous concentrations of arsenic in rock samples and stream-sediment samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon

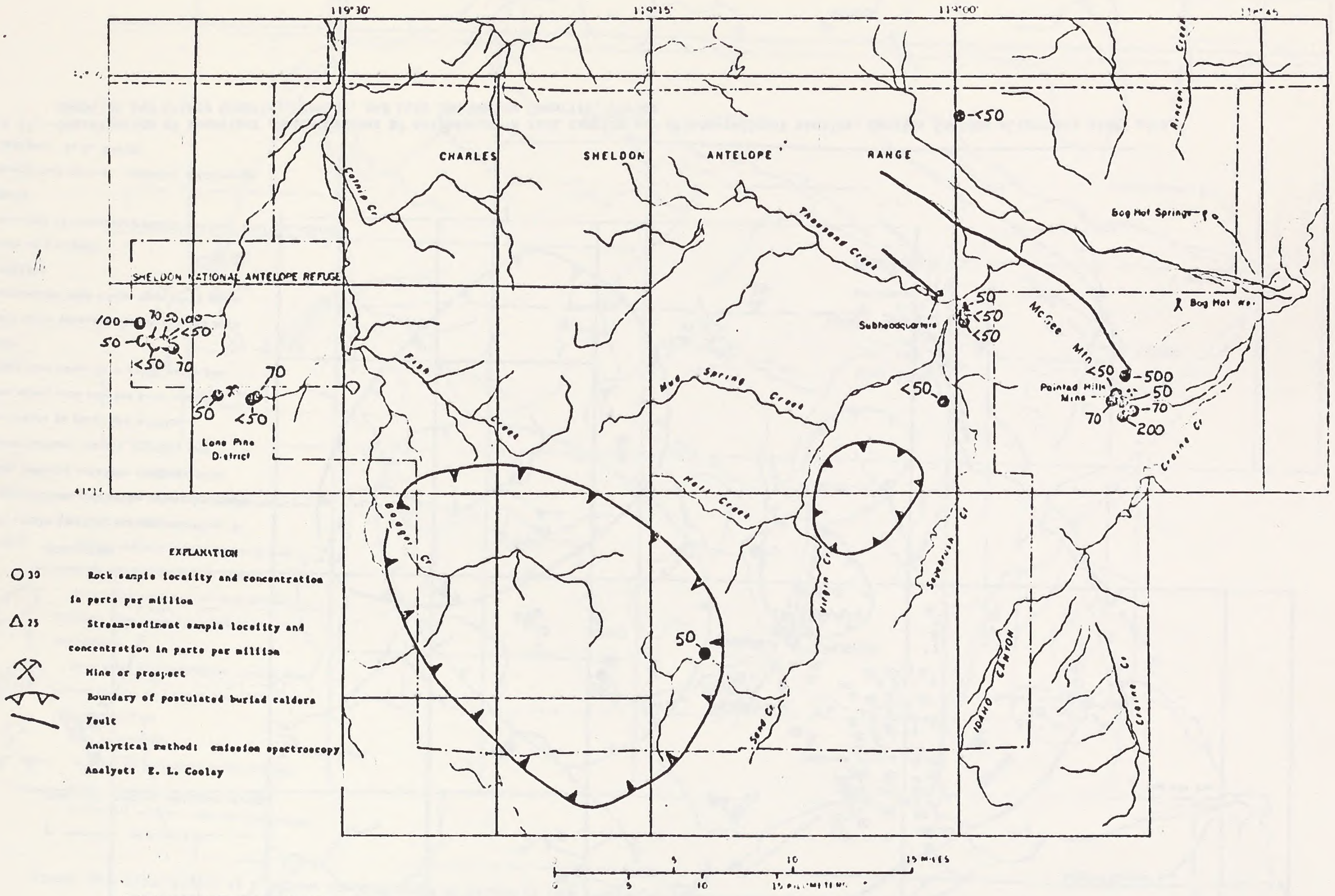
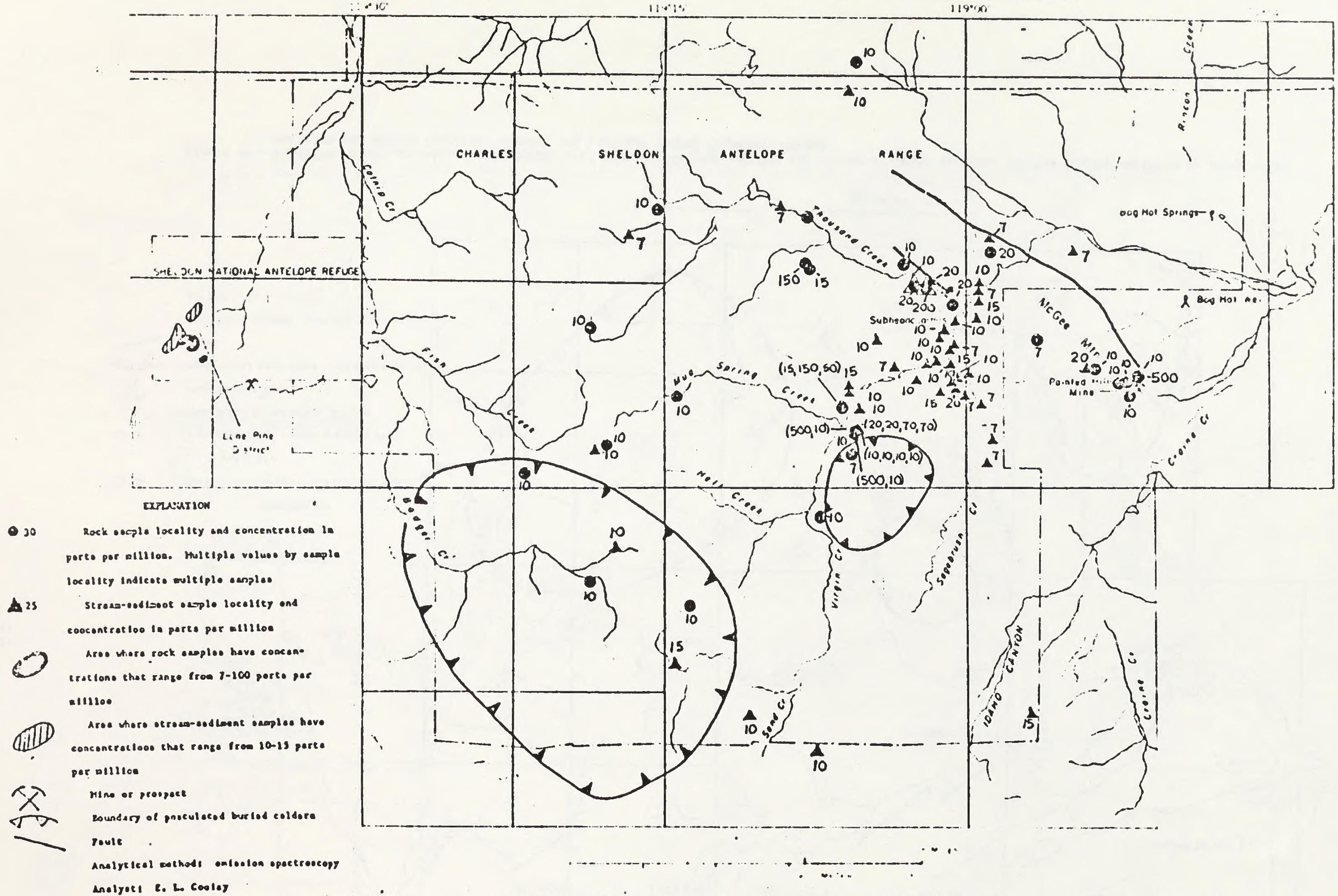

119°30'
119°15'
119°00'
118°45'
41°15'
CHARLES
SHELDON
ANTELOPE
RANGE
SHELDON NATIONAL ANTELOPE REFUGE
Bog Hot Springs
Bog Hot Res
Subheadquarters
McGee Mtn
Painted Hills Mine
Lone Pine District
Thousand Creek
Mud Spring Creek
Fish Creek
Hell Creek
Virgin Cr
Sawmill Cr
Sand Cr
Badger Cr
Colman Cr
Craine Cr
IDAHO CANYON
<50
50
<50
<50
<50
<50
500
50
70
70
200
100
70
100
100
50
<50
<50
70
50
70
<50
50
EXPLANATION
Rock sample locality and concentration in parts per million
Stream-sediment sample locality and concentration in parts per million
Mine or prospect
Boundary of postulated buried caldera
Fault
Analytical method: emission spectroscopy
Analyst: E. L. Cooley
0
5
10
15 MILES
15 KILOMETERS

Figure 16.--Distribution of anomalous concentrations of tungsten in rock samples and stream-sediment samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon



119°30'
119°15'
119°00'
CHARLES SHELDON ANTELOPE RANGE
SHELDON NATIONAL ANTELOPE REFUGE
Bog Hot Springs
Bog Hot Re.
Rincon Creek
Thousand Creek
Colapo Cr.
Fish Creek
Hog Spring Creek
Mell Creek
Badger Cr.
Virgin Cr.
Sagebrush Cr.
Sand Cr.
IDAHO CANYON
Craine Cr.
McGee Mtn
Painted Hills Mine
Subheonic mines
Lone Pine District
EXPLANATION
30 Rock sample locality and concentration in parts per million. Multiple values by sample locality indicate multiple samples
25 Stream-sediment sample locality and concentration in parts per million
Area where rock samples have concentrations that range from 7-100 parts per million
Area where stream-sediment samples have concentrations that range from 10-15 parts per million
Mine or prospect
Boundary of postulated buried caldera
Fault
Analytical method: emission spectroscopy
Analyst: E. L. Cooley

Figure 17.--Distribution of anomalous concentrations of molybdenum in rock samples and stream-sediment samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon

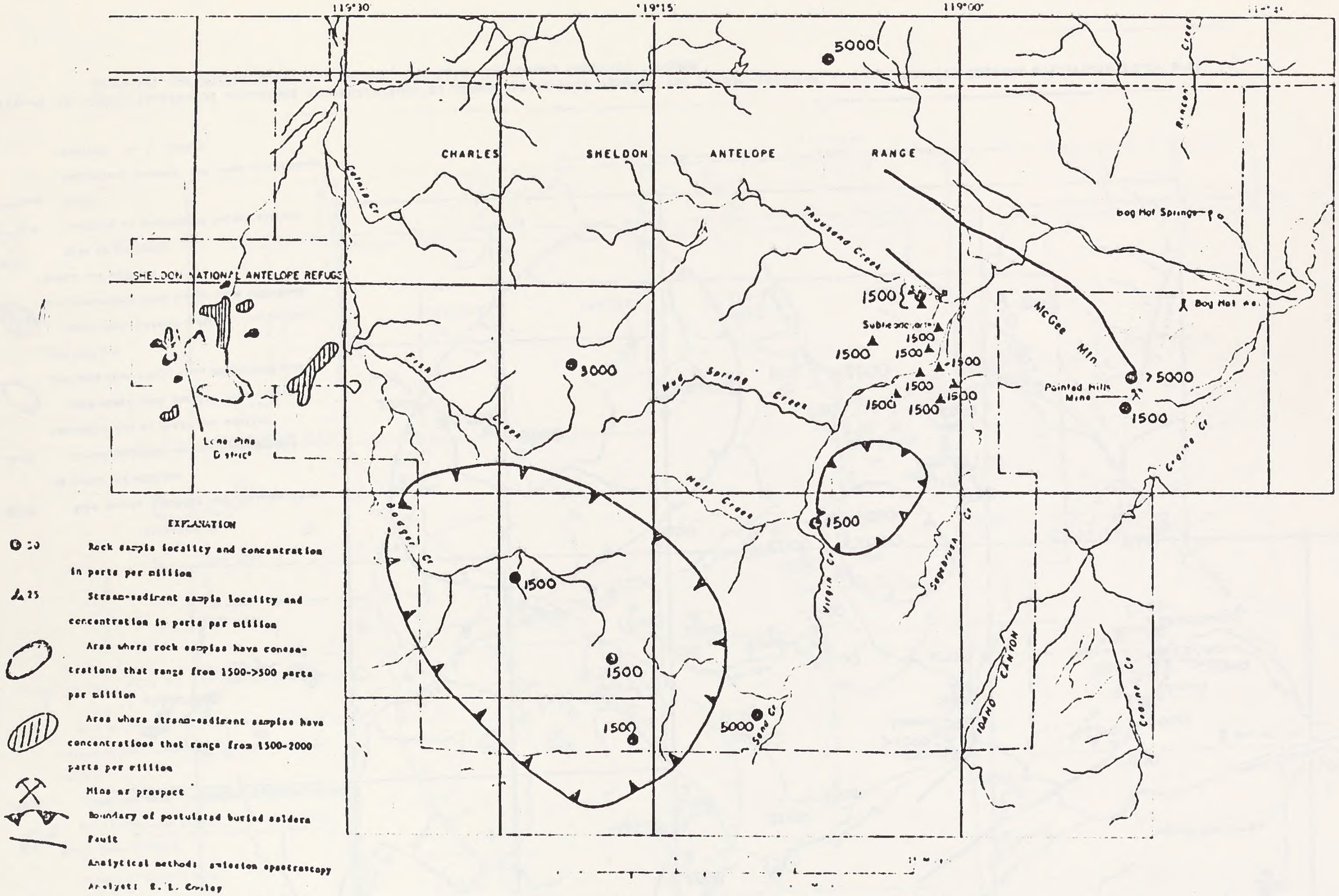
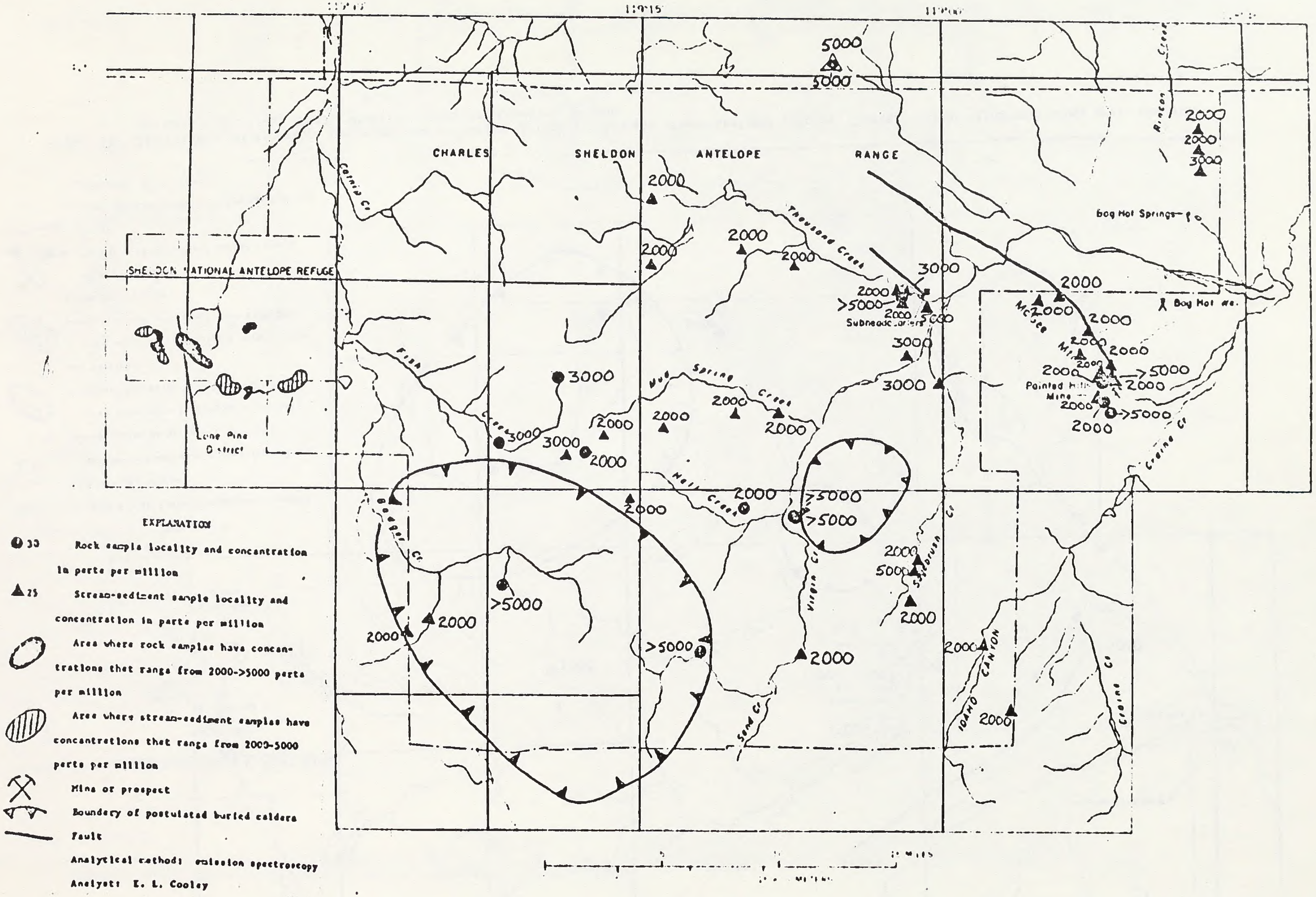

119°30'
119°15'
119°00'
CHARLES
SHELDON
ANTELOPE
RANGE
SHELDON NATIONAL ANTELOPE REFUGE
Lone Pine District
Catnip Cr
Fish Creek
Mud Spring Creek
Thousand Creek
Hell Creek
Virgin Cr
Sagebrush Cr
Sand Cr
Badger Cr
IDAHO CANYON
Cottonwood Cr
Rincon Creek
Bog Hot Springs
Bog Hot Res
McGee Mtn
Painted Hills Mine
Sublease
5000
3000
>5000
1500
EXPLANATION
Rock sample locality and concentration in parts per million
Stream-sediment sample locality and concentration in parts per million
Area where rock samples have concentrations that range from 1500->500 parts per million
Area where stream-sediment samples have concentrations that range from 1500-2000 parts per million
Mine or prospect
Boundary of postulated buried caldera
Fault
Analytical method: emission spectroscopy
Analyst: E. L. Cooley

Figure 18.--Distribution of anomalous concentrations of barium in rock samples and stream-sediment samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon



CHARLES
SHELDON
ANTELOPE
RANGE
SHELDON NATIONAL ANTELOPE REFUGE
Lone Pine District
Bog Hot Springs
Bog Hot Mine
Thousand Creek
Mud Spring Creek
Fish Creek
Hell Creek
Badger Cr
Virgin Cr
Sand Cr
Sagebrush Cr
Idaho Canyon
Craine Cr
Rincon Creek
Catnip Cr
McGee Mine
Painted Hills Mine
Subnode Mine
5000
2000
3000
>5000
EXPLANATION
Rock sample locality and concentration in parts per million
Stream-sediment sample locality and concentration in parts per million
Area where rock samples have concentrations that range from 2000->5000 parts per million
Area where stream-sediment samples have concentrations that range from 2000-5000 parts per million
Mine or prospect
Boundary of postulated buried caldera
Fault
Analytical method: emission spectroscopy
Analyst: E. L. Cooley

Figure 19.--Distribution of anomalous concentrations of manganese in rock samples and stream-sediment samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon

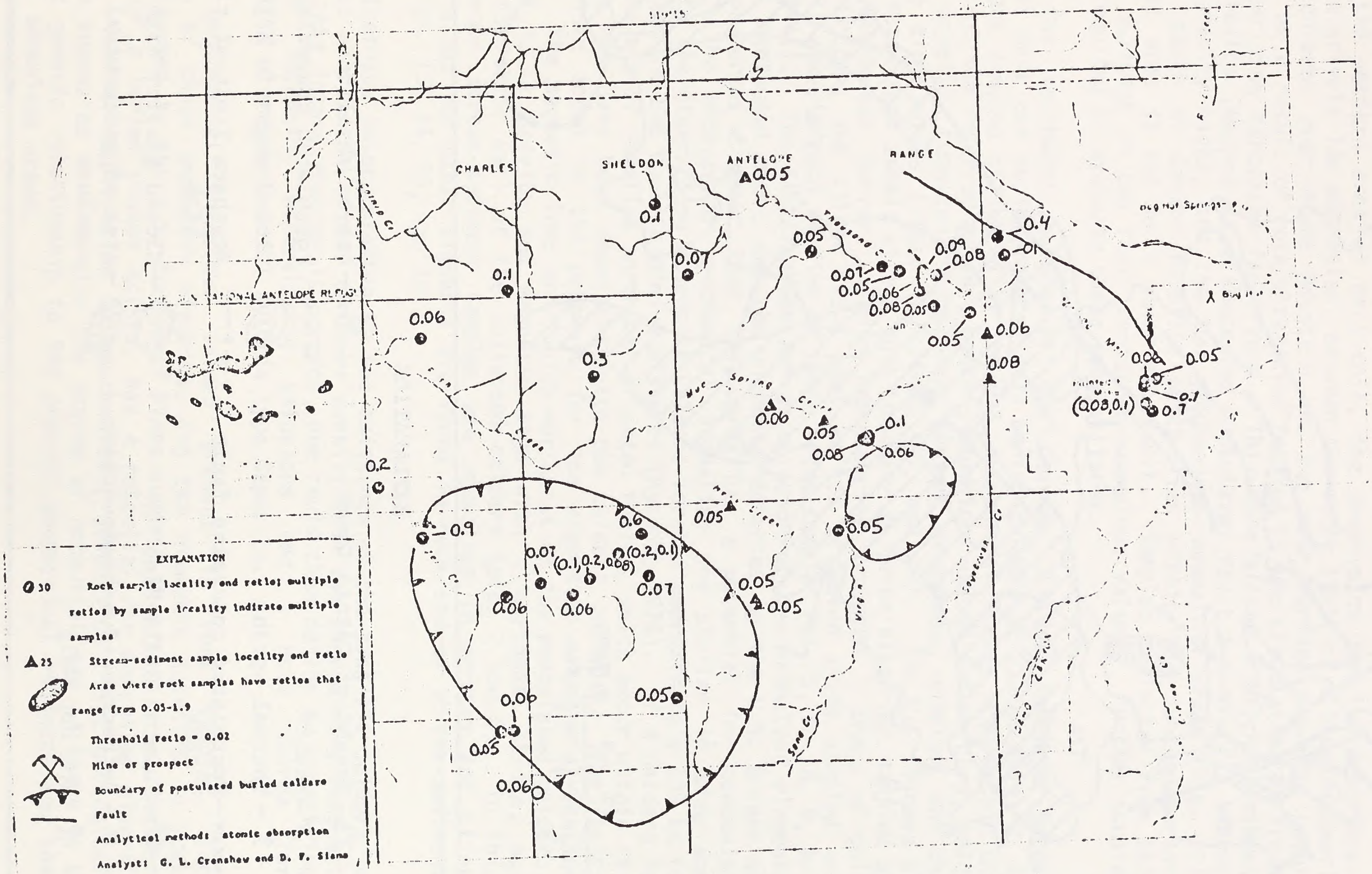
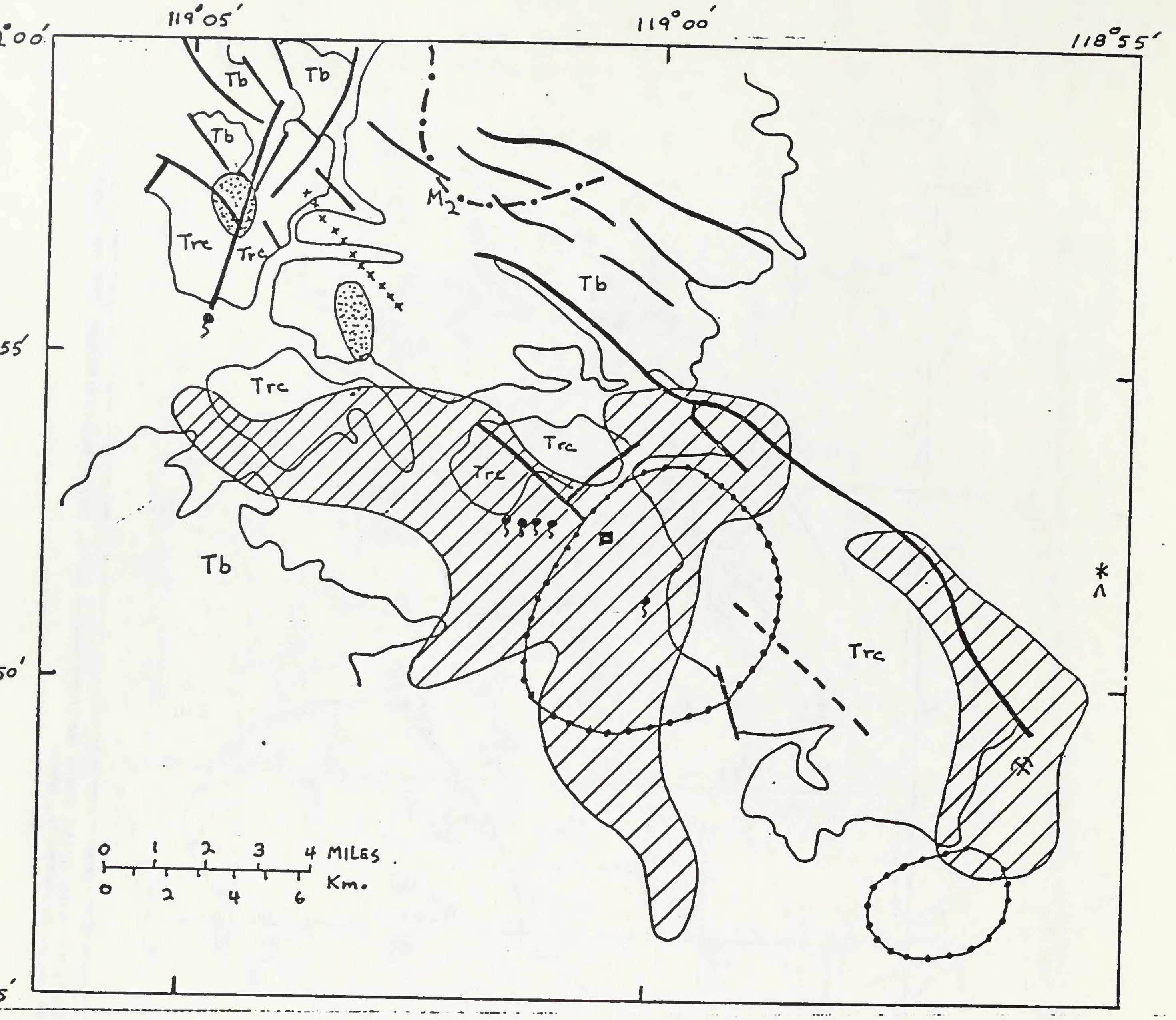

CHARLES
SHELDON
ANTELOPE
RANGE
SHELDON NATIONAL ANTELOPE REFUGE
Thousand Cr
Virgin Valley
Big Hot Springs
EXPLANATION
Rock sample locality and ratio; multiple ratios by sample locality indicate multiple samples
Stream-sediment sample locality and ratio
Area where rock samples have ratios that range from 0.05-1.9
Threshold ratio = 0.02
Mine or prospect
Boundary of postulated buried caldera
Fault
Analytical method: atomic absorption
Analyst: G. L. Crenshaw and D. F. Siems
0.05
0.1
0.07
0.1
0.06
0.3
0.05
0.07
0.05
0.06
0.08
0.09
0.08
0.05
0.4
0.1
0.05
0.06
0.08
0.05
0.1
0.7
(0.08,0.1)
0.06
0.05
0.1
0.08
0.06
0.05
0.2
0.9
0.6
0.07
(0.1,0.2,0.08)
(0.2,0.1)
0.07
0.06
0.06
0.05
0.05
0.05
0.06
0.05
0.06

Figure 20.--Distribution of anomalous cadmium to zinc ratios in rock samples and stream-sediment samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon


119°05'
119°00'
118°55'
55'
50'
Tb
Tb
Tb
Trc
Trc
M2
Tb
Trc
Trc
Trc
Tb
Trc
0 1 2 3 4 MILES
0 2 4 6 Km.

EXPLANATION

Tb	Basalt of Catnip Creek	Trc	Canyon rhyolite
/	Fault	- - -	Postulated concealed fault
ʢ	Thermal spring	⁘	Closed magnetic high
xxxx	Postulated concealed fault zone	•—•—•	Southern limit of closed magnetic high
⚒	Painted Hills Mine	⊙	Closed gravity high
■	Dufferrena Sub-headquarters	▨	Area of geochemical anomalous values
⚹	Bog Hot Well		

Figure 21. Relationship of geochemical anomalous areas of the Painted Hills Mine and the Sub-headquarters, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

In the western area of this unit, the geophysics section describes a zone of relatively low magnetism, between the outer limit of a broad magnetic maximum centered over Hawke Mountain and two near surface magnetic highs, which may be a result of rock alteration related to the circulation of fluids in an underlying concealed fault zone. This zone alines with the northwest trending faults (mapped as a concealed postulated fault F_3, pl. 2), thermal springs, gravity highs, and the two geochemical anomalous areas (fig. 21). The small patch of Canyon Rhyolite which lies within the Subheadquarters mineralized area is cut by a northwest fault. Samples collected from this rock unit adjacent to the fault contained anomalous values. Further studies would be required to evaluate these possibilities.

In the southwest corner of the Charles Sheldon Antelope Range, geophysical data can be interpreted as a buried caldera or pluton (pls. 2, 3, and 4). Rock samples collected by the U.S. Geological Survey from within the boundaries of the inferred caldera contain anomalous values for mercury, gold, antimony, arsenic, tungsten, molybdenum, barium, manganese, uranium, and the cadmium to zinc ratios (figs. 12, 14-20, 23, and 24). The U.S. Bureau of Mines collected rock sampls within this boundary at seven sites not sampled by the U.S. Geological Survey. Their laboratories reported a trace of gold (0.083-0.283 ppm) and silver (>2-4 ppm) at six of seven sites sampled and uranium (>10 ppm->50 ppm) at five of seven sites sampled (pl. 5, No. 8, 9, 36, 37, and 39-41). The distribution and association of the anomalous elements and ratios mentioned above and the elements detected by the U.S. Bureau of Mines laboratories suggest that this area has a potential for concealed deposits. The widespread geochemical anomalies are similar in size and magnitude to the mineralized McDermitt Caldera located approximately 132 km to the northeast in the Opalite mining district (Rytuba, 1976). If a caldera is present, the set of parallel northwest oriented faults, which occur within its boundaries, may have been associated with the caldera collapse. The faults then may have acted as the pathways for the migration of mineral-bearing solutions. The magnetic lows and faults northwest of the postulated caldera, interrupted by a gravity and magnetic high with a northeast strike, may represent the outer wall of the collapsed caldera (pls. 2 and 3). In this area, numerous stream-sediment samples are anomalous in mercury and a few anomalous values for other elements are found in rock and or stream-sediment samples (figs. 13, 14, 15, and 19).

An alternate interpretation to the existence of the possible caldera is the presence of a buried pluton of lower density than the surrounding basement rock. If this interpretation is correct, one could then define an underlying source for ascending mineralizing solutions and a heat source for remobilization of precious-metal sulfide type deposits.

The geochemical anomalous values present in rock samples, the association of these anomalous elements, and the elements detected in rock samples collected by the U.S. Bureau of Mines suggest that this area, whether a caldera or a buried pluton exists, has a potential for concealed mineral resources. Further exploration by geochemical, geophysical, and geological methods are suggested to determine the degree of potential and if there is a spatial and genetic relationship to the present geophysical evidence and the geochemical anomalous areas.

Figure 22 shows a northwest-trending chain of mafic vents, palagonite tuff rings, and a low shield volcano which appear to aline with five volcano vents, to the southeast, described by Korringa (1973). This northwest-trending chain appears to lie between magnetic highs and to be associated with magnetic lows and the postulated caldera or buried pluton. A northwest fault system has a similar relationship. The association of these features with each other outlines a more than 80 km northwest-trending lineation. This linear feature may represent a major structural zone at depth. If this structural feature does exist and if it is a zone of weakness in the earth's crust, then alternate channels for the ascending mineral solutions seem plausible.

Anomalous concentrations of mercury, antimony, arsenic, molybdenum, barium, manganese, and anomalous ratios of cadmium to zinc and detectable gold are found in the Hell Creek drainage basin and in the area contiguous with the junction of Hell Creek and Virgin Creek (figs. 12-15, 17-20, and 23). Most of the valley of Hell Creek from its source to its junction with Virgin Creek is fault controlled. The anomalous amounts of elements and ratios mentioned above, as well as several mercury prospects, seem to be associated with the faults. The area near the junction of Hell Creek and Virgin Creek is contiguous with C_2 a geophysical anomaly (pl. 2).

The U.S. Bureau of Mines collected numerous rock samples at eight sample sites not visited by the U.S. Geological Survey in the Hell Creek drainage basin and on the eastern borders of the C_2 geophysical anomalous area (pl. 5, No. 13, 28, 31, 32, 33, 34, 35, and 38). Their laboratories report that the silver values in rocks ranged from a trace (>2-4 ppm) to 16 ppm at 5 of the eight sites sampled. A trace of gold (0.08 - 0.2 ppm) was detected at three sites, uranium (10-400 ppm), at four sites, and manganese (400-100,000 ppm) at one site.

The geochemical anomalous values detected in rock and stream-sediment samples, the elements reported in rock samples collected by the U.S. Bureau of Mines, the association of these elements, and the proximity of the sample sites to the C_2 geophysical anomalous area, mercury prospects and faults suggest possible potential areas for concealed deposits exist in this area.

The headwater drainage basins of Sagebrush Creek, Thousand Creek, and Mud Creek are other areas where anomalous concentrations of some of the elements discussed earlier in the text occur in stream-sediments and rocks (figs. 12-20, and 23).

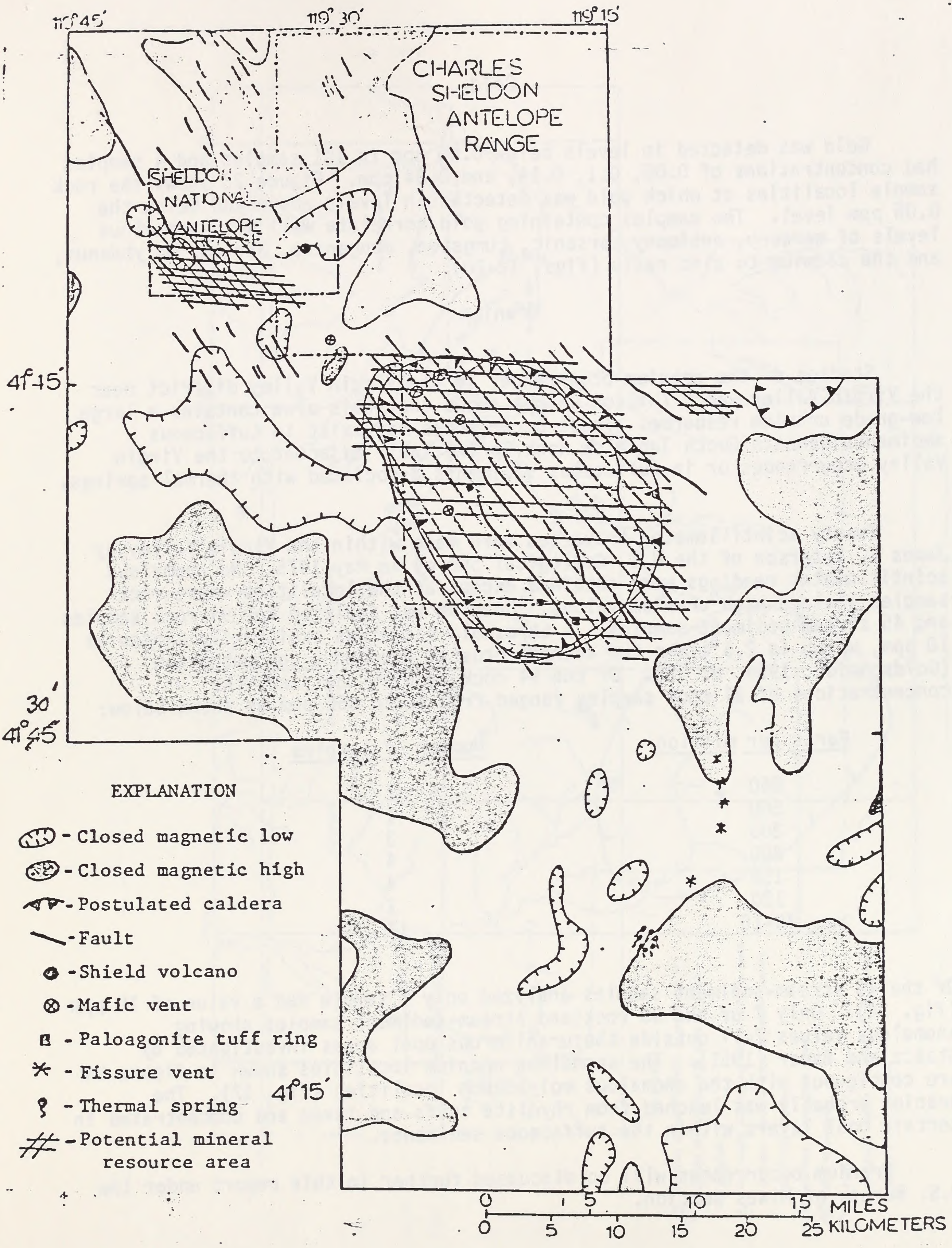

119°45′
119°30′
119°15′
CHARLES SHELDON ANTELOPE RANGE
SHELDON NATIONAL ANTELOPE REFUGE
41°45′
30′
41°15′
EXPLANATION
- Closed magnetic low
- Closed magnetic high
- Postulated caldera
- Fault
- Shield volcano
⊗ - Mafic vent
- Paloagonite tuff ring
* - Fissure vent
- Thermal spring
- Potential mineral resource area
0 5 10 15 MILES
0 5 10 15 20 25 KILOMETERS

Figure 22. Relationship of geophysical, geological, and potential mineral resource areas in the western part of the Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Gold

Gold was detected in levels below 0.05 ppm in 101 samples and 4 samples had concentrations of 0.06, 0.1, 0.14, and 0.84 ppm. Figure 23 shows the rock sample localities at which gold was detected in levels above and below the 0.05 ppm level. The samples containing gold correlate well with anomalous levels of mercury, antimony, arsenic, tungsten, manganese, barium, molybdenum, and the cadmium to zinc ratio (figs. 12-20).

Uranium

Studies of the uranium occurrences in the Virgin Valley district near the Virgin Valley Ranch (Wilson Ranch) shows that this area contains a large low-grade uranium resource. These occurrences may exist in tuffaceous sediments beneath Gooch Table or Rock Spring Table adjacent to the Virgin Valley occurrences or in tuffaceous sediments associated with thermal springs.

Twenty scintillometer traverses were made within the Virgin Valley by James E. Peterson of the U.S. Geological Survey in May 1975. No anomalous scintillometer readings were obtained except at the localities where rock samples yielded high uranium values. Uranium was analyzed for 94 rock samples and 45 stream-sediment samples. A threshold value was arbitrarily chosen as 10 ppm, which is 2.5 times the average crustal abundance concentration (Goldschmidt, 1954, p. 75). Of the 94 rock samples analyzed, the concentrations of 37 rock samples ranged from 10 to 860 ppm as shown below:

Parts per million	Number of samples
860	1
500	1
300	3
200	4
150	4
100	7
70-10	17

Of the 45 stream-sediment samples analyzed only 1 sample had a value of 10 ppm (fig. 24). Only 7 of the 38 rock and stream-sediment samples showing anomalous values fall outside the uraniferous opal areas investigated by Staatz and Bauer (1951). The anomalous uranium localities shown in figure 24 are contiguous with the anomalous molybdenum localities (fig. 17). The uranium probably was leached from rhyolite tuffs and lavas and concentrated in certain opal layers within the tuffaceous sediments.

Uranium occurrences will be discussed further in this report under the U.S. Bureau of Mines section.

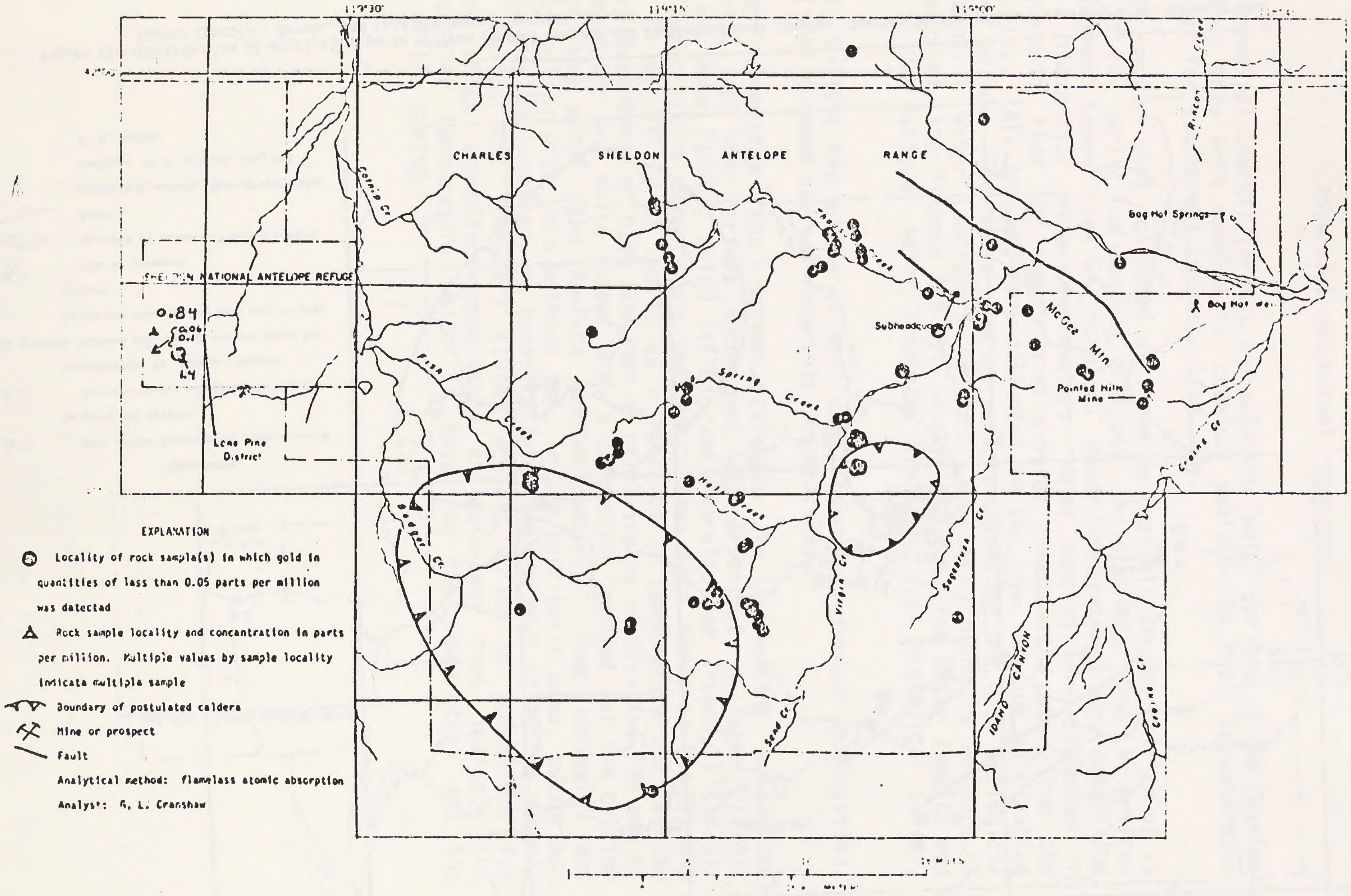

119°30'
119°15'
119°00'
CHARLES
SHELDON
ANTELOPE
RANGE
SHELDON NATIONAL ANTELOPE REFUGE
0.84
0.06
0.1
4.4
Lone Pine District
Colvin Cr
Fish Creek
Badger Cr
Spring Creek
Hell Creek
Sand Cr
Virgin Cr
Sagebrush Cr
IDAHO CANYON
Craine Cr
Rincon Creek
Bog Hot Springs
Bog Hot Well
McGee Mtn
Pointed Hills Mine
Subheadquarters
EXPLANATION
Locality of rock sample(s) in which gold in quantities of less than 0.05 parts per million was detected
Rock sample locality and concentration in parts per million. Multiple values by sample locality indicate multiple sample
Boundary of postulated caldera
Mine or prospect
Fault
Analytical method: flameless atomic absorption
Analyst: G. L. Crenshaw
10 MILES

Figure 23.--Localities of rock samples in which gold was detected, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

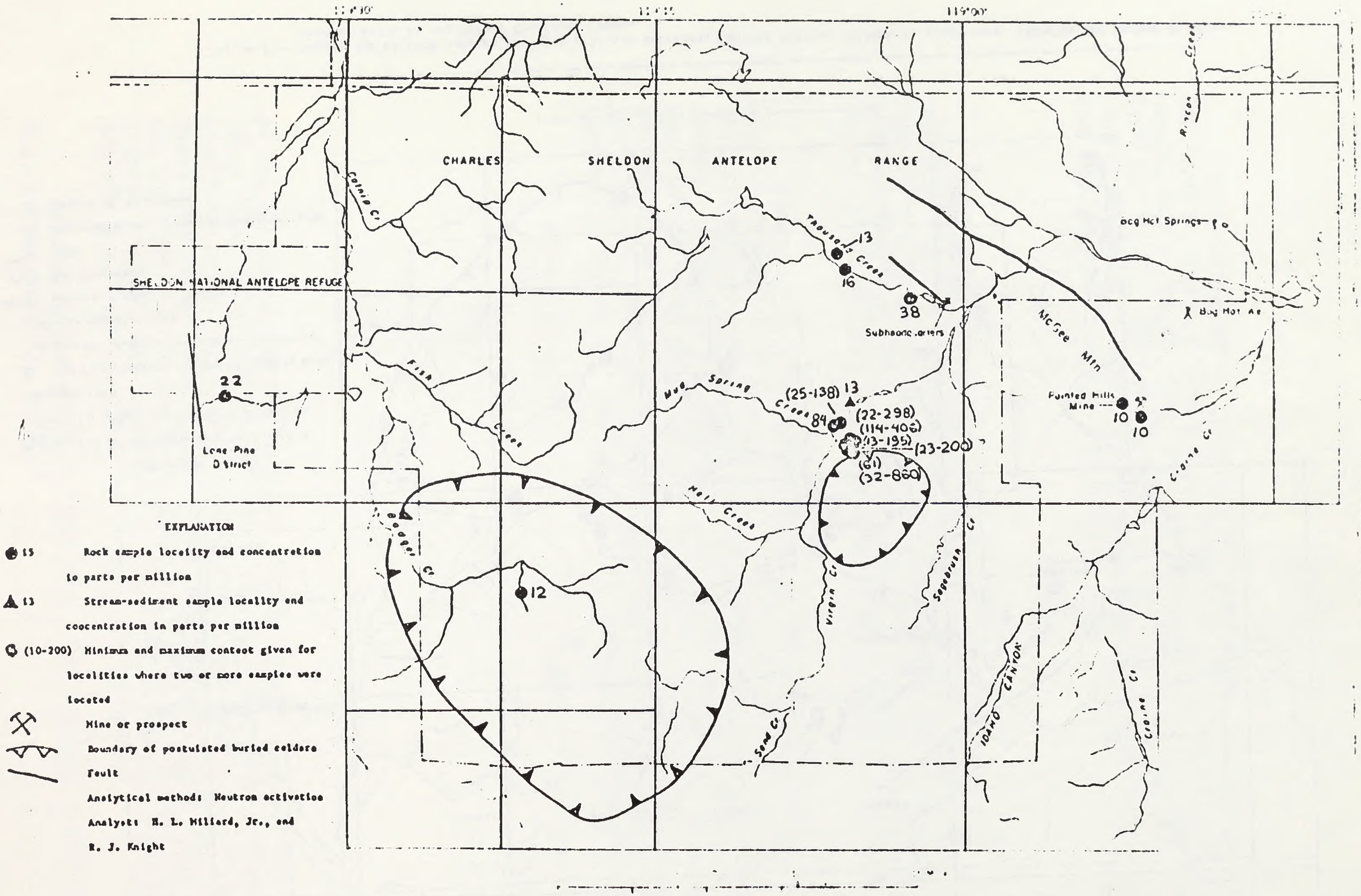

119°00'
CHARLES
SHELDON
ANTELOPE
RANGE
SHELDON NATIONAL ANTELOPE REFUGE
Colbie Cr
Fish Creek
Mud Spring Creek
Thousand Creek
Hell Creek
Virgin Cr
Sagebrush Cr
Sand Cr
Badger Cr
IDAHO CANYON
Craine Cr
Rincon Creek
Bog Hot Springs
Bog Hot Ax
McGee Mtn
Painted Hills Mine
Subheadquarters
Lone Pine District
22
13
16
38
13
84
(25-138)
(22-298)
(114-406)
(13-195)
(23-200)
(61)
(32-860)
10
10
12
EXPLANATION
15 Rock sample locality and concentration in parts per million
13 Stream-sediment sample locality and concentration in parts per million
(10-200) Minimum and maximum content given for localities where two or more samples were located
Mine or prospect
Boundary of postulated buried caldera
Fault
Analytical method: Neutron activation
Analysts: H. L. Millard, Jr., and R. J. Knight

Figure 24.--Distribution of uranium ≥10 parts million in rock samples and stream-sediment samples, Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon

Potential geothermal resources

The principal thermal springs and adjacent "cold" springs of the Charles Sheldon study area were sampled for chemical analyses in order to determine the potential for geothermal resource (fig. 1B).

Water samples were collected as close as possible to the orifice of 11 springs. If the spring had several orifices, the discharge from the orifice with the highest temperature was sampled. Water temperatures were determined by using a thermistor probe thermometer. Water samples were collected in liter containers that had been rinsed several times with water from the sampled spring. All samples were collected on the same day and no fixating agents were added. The water samples were analyzed by the U.S. Geological Survey's Central Water Laboratory in Salt Lake City, Utah, by methods of Brown, Skougstad, and Fishman (1970). Analytical data for water samples are on file in the National Water Resources Division, U.S. Geological Survey, Virginia.

Table 5 lists the spring or well name, location, chemical composition, and calculated minimum thermal-reservoir temperatures.

Water chemistry has proved valuable in estimating subsurface temperatures, and the various techniques are described by Mahon (1970), Fournier and Rowe (1966), White (1970), and Fournier and Truesdell (1973). The most quantitative temperature indicators have been shown to be (1) the variation in solubility of quartz as a function of temperature and (2) the temperature dependence of base exchange or partitioning of alkalies (Na and K) between solutions and solid phases with a correction applied for the calcium content of the water (the Na-K-Ca geothermometer). Some ambiguity and uncertainty exists with both methods and, in any particular area, subsurface information may be necessary in order to determine the most effective method. Fournier, White, and Truesdell (1974) present a set of guidelines for determining which subsurface-temperature estimate may best indicate the thermal-aquifier temperature which is based on the temperature and the discharge of the spring.

Table 5. Location, chemical composition, and calculated minimum thermal-reservoir temperatures of springs in the Charles Sheldon wilderness study ar Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon

[Analyses by U.S. Geological Survey, methods of analyses of Brown, Skougstad, and Fishman (1970); temperatures in degrees celsius (C). Springs are identified on the following topographic quadrangles: A-H, Big Springs Butte; J-K, Railroad Point; and L, Denio]

Spring or Well Latitude, Longitude	Temperature (C)	Milligrams Per Litre																						Calculated Reservoir Temperature	
		Cations				Anions																			
		Calcium (Ca)	Magnesium (Mg)	Potassium (K)	Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Chloride (Cl)	Flouride (F)	Sulfate (SO_4)	Alkalinity as $CaCO_3$	Hardness Total (Ca, Mg)	Hardness Non-carbonate	Silica (SiO_2)	Lithium (Li)	Boron (B)	Antimony (Sb)	Arsenic (As)	Mercury (Hg)	Calculated sum of dissolved residues	Dissolved Solids (Tons per acre foot)	Sodium Adsorbtion Ratio	Percent of Sodium	Silica Conductive-Cooling Geothermometer (C)	Sodium-Potassium-Calcium Geothermometer (C)
A. Virgin Valley Campground 1 41°51'12", 119°00'03"	32	3.7	0	0.4	29	64	0	4.7	1.8	12	52	9	0	32	0.03	0.08	0.002	0.007	0.0000	115	0.16	4.2	87	82	26
B. Roadside Rest 2 41°52'34", 119°02'25"	18	1	0	1.8	31	69	0	4.9	1	9	57	3	0	54	.03	.07	.000	.010	.0000	137	.19	8.5	93	105	96
C. Roadside Rest 3 41°52'31", 119°02'51"	18	2.1	0.1	2.8	31	74	0	5	.9	9	61	6	0	57	.02	.07	.000	.014	.0000	144	.20	5.7	88	108	93
D. Roadside Rest 4 41°52'28", 119°02'45"	17	12	.7	3.7	32	109	0	6	.8	10	89	33	0	56	.03	.07	.000	.019	.0000	175	.24	2.4	65	107	65
E. Roadside Rest 5 41°52'29", 119°02'42"	17	2.7	.2	2.9	30	73	0	5.2	.9	9.1	60	8	0	57	.02	.07	.000	.018	.0000	144	.20	4.7	85	108	89
F. Big Springs Cold 6 41°55'25", 119°09'30"	13	5.3	1.1	2.4	8.2	34	0	3.1	.2	4.3	28	18	0	32	.002	.05	.001	.002	.0001	73	.10	.8	46	82	55
G. Virgin Valley Ranch Hot 10 41°47'26", 119°06'27"	21	3.2	.3	4	21	50	0	5.9	.6	11	41	9	0	53	.01	.08	.002	.008	.0000	124	.17	3	76	105	92
H. Virgin Valley Ranch Cold 11 41°48'16", 119°05'26"	10	3.0	.6	7.4	45	90	0	11	.5	28	74	10	0	54	.02	.09	.000	.012	.0000	194	.26	6.2	83	105	201
J. Bog Hot 7 41°55'25", 118°48'16"	54	0	0	.9	77	125	0	15	1.7	46	103	0	0	56	.02	.71	.004	.033	.0000	259	.35	.0	99	107	101
K. Bog Cold 8 41°55'57", 118°48'29"	10	11	1.8	12	56	145	0	19	1	17	119	35	0	56	.02	.10	.000	.020	.0000	260	.35	4.1	71	107	209
L. Baltazor Hot 9 41°55'18", 118°42'33"	83	14	.2	8.6	180	163	0	48	6.6	220	134	36	0	130	.20	2	.007	.180	.0007	690	.94	13	89	152	147

Lacking knowledge of subsurface reactions and discharge rate, calculated subsurface temperatures were determined using both the quartz solubility and Na-K-Ca geothermometers. For the quartz solubility geothermometer (from Fournier and Rowe, 1966), the empirical equation is

$$T^o_C = \frac{1.30 \times 10^3}{5.19 - \log_{10} C_{SiO_2} \text{ (aq)}} - 273$$

where $T^o{}_C$ = temperature in centigrade, and

C_{SiO_2} = concentration of silica in milligrams per liter and

aq = aqueous

For calculations of subsurface temperatures from Na-K-Ca concentrations (from Fournier and Truesdell 1973), the equation is

$$T^o_C = \frac{1647}{\log_{10}(M_{Na}{}^+/M_K{}^+) + \beta \log(\sqrt{M_{Ca}{}^{+2}}/M_{Na}{}^+)} - 2.24$$

where T^o_C = temperature in centigrade, and

$M_{Na}{}^+$ = molality of sodium ion,

$M_K{}^+$ = molality of potassium ion,

$M_{Ca}{}^{+2}$ = molality of calcium ion, and

β = 1/3 for water equilibrated above 100°, and

β = 3/4 for water equilibrated below 100°.

Test to see if β = 4/3 yields a temperature below 100°C; if it does not, use β=1/3 to estimate the equilibration temperature. Molality is a molal concentration (one mole of solute per 1,000 grams of solvent).

The results of these calculations for individual springs are given in table 4. The quartz conductive-cooling geothermometer shows a range of 82°C to 152°C. The Na-K-Ca geothermometer shows a range of 26°C to 209°C. The difference between temperatures measured by the two geothermometers methods for any one spring ranges from 5°C to 102°C. The median of the ranges is 35°C. The maximum temperatures calculated are 152°C for the quartz conductive method and 209°C for the Na-K-Ca method. The subsurface temperatures calculated by the quartz conductive method are low compared with subsurface temperatures of geothermal fields presently being exploited. These temperatures are below the minimum temperature of 180°C currently thought necessary to drive steam-turbine generators (Muffler, 1973). All but two of the subsurface temperatures calculated by the Na-K-Ca geothermometer method are lower than the 180°C. Although the subsurface temperatures calculated by both methods are low, except for the two mentioned above, a system has been devised whereby the geothermal heat is used in a heat exchanger to boil a secondary fluid (as a gas) to drive a turbine. This fluid is then condensed and returns to the heat exchanger (Jonsson and others, 1969). A generating unit based on the heat-exchange principle and using intake water of 81°C is reported by Faaca (1972).

Springs with surface temperatures below boiling may be either a mixed water or water which has equilibrated at depth with rock only slightly hotter than the measured spring temperature. The mixed waters are produced by mixing the high temperature water greater than 100°C with cold meteoric water. Thus, the thermal-aquifier temperature estimated from the water compositions may be below the actual true minimum thermal-reservoir temperature at depth.

Surface data suggests the area has a low potential for geothermal resources. All springs in the Sheldon study area had surface temperatures below boiling. If mixed waters are involved, the estimated minimum thermal-reservoir temperatures may be low, and the area could have a moderate to good potential for geothermal resources. Subsurface measurements and drilling would be required to evaluate the latter possibility.

As reported in the geophysical section of this report, gravity highs occur near five thermal or warm springs (fig. 1C--springs A, G, I, J, and L). These springs, except one near Gridley Lake, and seven others were sampled and their waters were analyzed. The seven additional springs (fig. 1C--springs B, C, D, E, F, H, and K) are also associated with these and other gravity highs. There is no consistent correlation between magnetic anomalies and the location of these springs. If local gravity highs indicate young buried intrusive centers, one could define the underlying source that heats the water; however, no young intrusive rocks or other intrusive rocks are exposed at the surface. Therefore, the relationship between these springs and gravity highs remains speculative.

The concept for the origin of hot springs in northern Nevada involves a cycle of descending meteoric water, heating at depth by the high geothermal gradient, then ascending along faults; therefore, structure would be much more important control of geothermal systems than "local heat sources." The area between the major fault along the McGee Mountain front and the postulated buried fault beneath the Canyon Rhyolite on McGee Mountain suggests a possible horst or doming structure. These faults could be part of the channelways for both the ascending mineralizing solutions discussed earlier and the ascending thermal waters.

Thermal water is water generally from a spring whose temperature is appreciably above the local mean annual temperature. If mixed waters are involved in this area, other springs not sampled may not fit this general definition. The location of Bog Hot Well in the alluvial fan northeast of the McGee Mountain fault suggests that springs along this fault may be of thermal origin as is also suggested by the steam emission reported from a drill hole in the vicinity of this fault near the Painted Hills Mine (Wendell, 1970, p. 98).

The surface data, the estimated minimum thermal-reservoir temperatures which may be low if mixed waters are involved, the possibility that springs not sampled are of thermal origin, and the speculations concerning heat sources for these waters indicate that the area could have a low to moderate potential for geothermal resources.

MINERAL RESOURCES OF THE CHARLES SHELDON WILDERNESS STUDY AREA, HUMBOLDT AND WASHOE COUNTIES, NEVADA, AND LAKE AND HARNEY COUNTIES, OREGON

ECONOMIC APPRAISAL

By E. T. Tuchek, F. J. Johnson, and M. D. Conyac,

U.S. Bureau of Mines

SETTING

The Charles Sheldon wilderness study area is in the northwest corner of Nevada. The area is underlain by volcanic rocks consisting of basalt, rhyolite, andesite, and associated ash, tuff, and tuffaceous sandstone. Within the study area are two mining districts: The Virgin Valley near the eastern edge of the range, and the Lone Pine in the southern part of the refuge (fig. 25).

Significant deposits of precious opal are found at the Rainbow Ridge Opal, Royal Peacock Opal, and Virgin Opal (Bonanza) mines, of the Virgin Valley district.

Humboldt and Washoe county records list more than 1,656 lode and 98 placer claims within the study area. Three hundred ninety-three are active. The placers were all located for precious opal. The earliest known prospecting in the study area took place in the Lone Pine district in 1897. Many claims have been relocated, some several times. Six were patented in 1929.

Claims are concentrated in the Lone Pine and Virgin Valley districts, with smaller clusters, located mainly for uranium, throughout the study area.

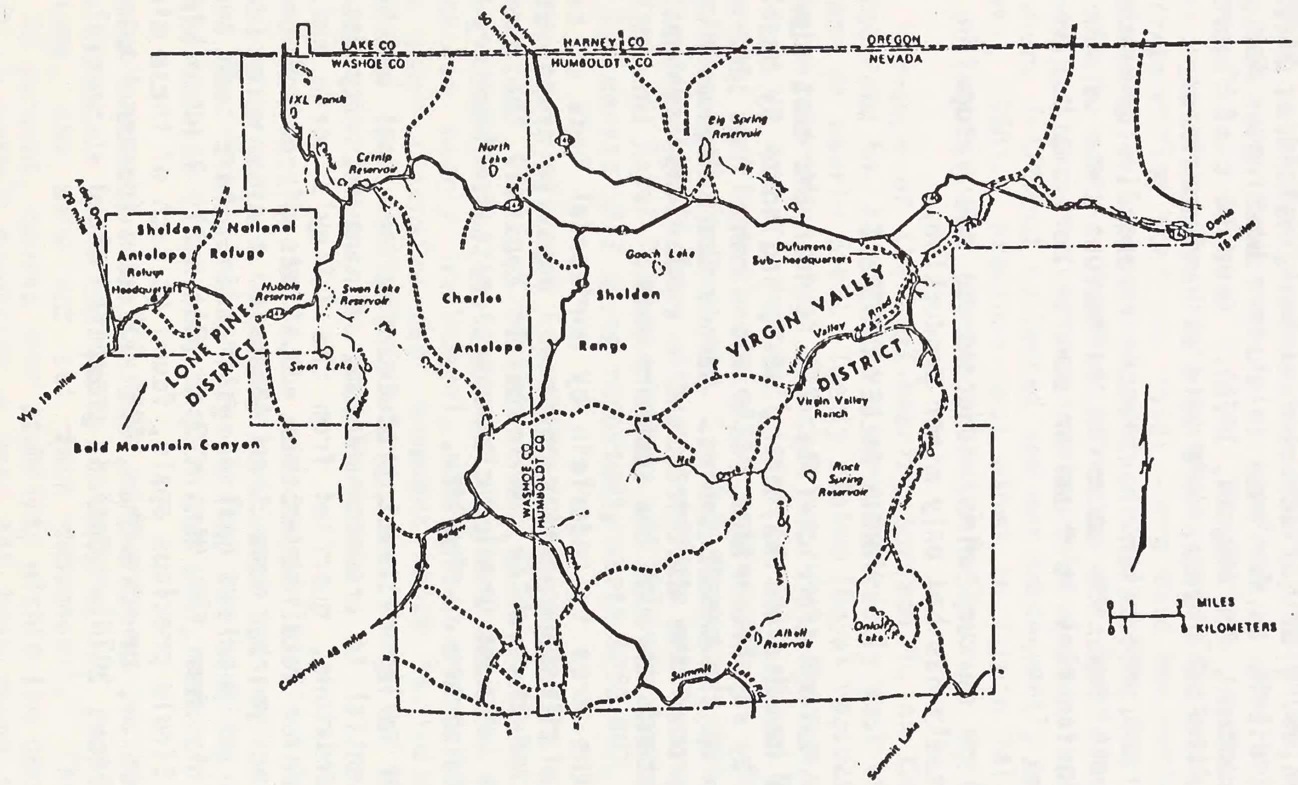

LAKE CO
WASHOE CO
HARNEY CO
HUMBOLDT CO
OREGON
NEVADA
Lakeview 50 miles
IXL Ponds
Catnip Reservoir
North Lake
Ely Spring Reservoir
Sheldon National Antelope Refuge
Refuge Headquarters
Hubble Reservoir
Swan Lake Reservoir
Swan Lake
LONE PINE DISTRICT
Charles Sheldon Antelope Range
Gooch Lake
Dufurrena Sub-headquarters
VIRGIN VALLEY DISTRICT
Virgin Valley Ranch
Rock Spring Reservoir
Alkali Reservoir
Onion Lake
Summit
Summit Lake
Cedarville 48 miles
Adel, Ore. 70 miles
Vya 19 miles
Denio 15 miles
Bald Mountain Canyon
WASHOE CO
HUMBOLDT CO
MILES
KILOMETERS

Figure 25.--Map showing mining districts. Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Nearly all past mineral production in study area, estimated to have been worth several millions of dollars, has been from the Virgin Valley district. Raw and finished precious opal accounted for more than 75 percent of the total. Over 16,000 t of tuffaceous sandstone, valued at $66/t retail, have been shipped to cities as far away as eastern Washington for use as building facings (oral commun., Bob Wegman, 1976). Over 14 t of fluorescent opalite, found on the April Fool claims, were sold as hand specimens.

Although no production has been recorded, low-grade uranium and diatomaceous earth deposits occur in tuffaceous beds of the Virgin Valley district. Bentonite clay is found in several horizons but is of low quality and has no value.

The Antelope mercury mine, adjacent to the refuge in the Lone Pine district, reportedly has had only minor production.

VIRGIN VALLEY DISTRICT

The Virgin Valley district (fig. 25) is near the east edge of the range. The district is bounded on the north, west, and south by basalt table lands and on the east by rhyolite ridge. Elevations range from 1460 m on the valley floor to 1860 m on the basalt tables. Nevada State Highway 8A passes through the northern part of the district, and a road along Sagebrush Creek toward Virgin Valley extends through the southern part.

Most of the area is underlain by horizontal beds of bentonite, ash, tuff, tuffaceous siltstone, and sandstone. Rhyolite crops out on the north and east sides of the valley, while basalt caps all the surrounding table lands. All opal and most uranium claims are on the sedimentary beds; however, a few uranium claims are on rhyolite.

The Virgin Valley district produced precious opal and building stone, and has the potential to produce uranium. Mining activity dates back to the 1870's, when sandstone, quarried from the valley's north end, was used as building material on local homesteads. Opal was discovered in 1905 or 1906; in the following years, more than 486 opal claims were located. Total production value of precious opal is estimated to have been several millions of dollars, mainly from the Virgin Opal (Bonanza), Rainbow Ridge, and Royal Peacock mines. Single precious opals, found at each of these mines, have been valued at as much as, or more than, $250,000 each (personal comm., K. Hodson, 1975, and H. Wilson, 1976). Opal is presently mined at several localities in the district.

Field investigations show that precious opal is associated with a bentonitic horizon that formed as a result of airborne ash and tuff falling into Miocene Lakes (Merriam, 1910). Common opal is not restricted to one horizon. The bentonite is light gray to green and contains varying amounts of ash, sand, rhyolite pebbles, and petrified wood. Limonite and manganese stain and fibrous gypsum are found on joint surfaces. The thickness of the bentonitic horizon is as much as 2.4 m. The horizon is divided into three zones: an upper zone with very little partially-petrified wood, a middle zone having partially-petrified wood and voids where wood has rotted away, and a lower zone containing well-petrified wood. Most of the precious opal fills voids in the middle zone. These occurrences are found in pockets. The pockets are theorized to mark the locations of calm places along the shores of ancient lakes where driftwood collected and was subsequently covered with ash (Hodson and Dake, 1950). Precious opal mined in Virgin Valley is usually found as casts of limbs, twigs, cones, or small logs.

The best exposure of the opal-bearing horizon is on the east side of Virgin Creek from Pond No. 13 south to a canyon directly east of Virgin Valley Ranch, a distance of nearly 5 km. Twenty claims (Royal Peacock Nos. 1 and 2, Kelly No. 1, Skajwm, Northern Light, Peacock Nos. 2-4, Phantom, Pebble, Little Pebble, Angel Nos. 1 and 2, Red Ball, Yellow Ball, Blue Ball, Starfire, Starbright, Beckey, and Mucket) are along this exposure. Mining has been concentrated on the Royal Peacock Nos. 1 and 2, Northern Light, Pebble, Angel No. 1, Beckey, and Mucket claims, with most of the precious opal coming from the Northern Light and Royal Peacock claims. In 1970 the famous Royal Peacock opal, weighing 191 carats 38.2 g and reportedly worth $250,000, was found.

Another opal-bearing area, one which includes the Virgin Opal (Bonanza) mine, is northwest of Virgin Creek and about 6 km southwest of Duffurrena Subheadquarters. Unlike the east side of Virgin Creek area where the opal-bearing horizon is nearly horizontal, the area around the Virgin Opal (Bonanza) mine shows extensive past movement which is indicated by slump blocks. A broken opal, weighing 3.3 kg, was found at the Virgin Opal (Bonanza) mine by Keith Hodson, the present owner.

The Rainbow Ridge mine is on the east side of Virgin Valley campground. Here the opal-bearing horizon is nearly horizontal and averages more than 1.2 m in thickness. Two exceptionally large opals, the Roebling and the Hodson, were found at the Rainbow Ridge mine in 1917 and 1952, respectively.

The district's precious opal is some of the finest in the world, both in color and opalescence. In the past, most precious opals were sold as collector's items, and were not cut into cabochons[1]. Their high water content, 16 to 23 percent, causes poor stability within the gem. According to Harry W. Wilson, a method requiring a year has been found to reduce water content to less than 5 percent without damaging the gem.

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[1] A gem cut in convex form and highly polished, but not faceted.

A quarry on the Lemac group of claims in the northern part of the district has produced dimension stone. Permission for the Bureau of Mines to examine the claims was not received. The reddish brown, tuffaceous sandstone is relatively unfractured, splits easily along bedding planes, and is as much as 6 m thick (Wendell, 1969). Beyond the claims' boundaries, the sandstone unit thins rapidly to a thickness of 0.8 mm and becomes a poor quality ornamental stone. However, resources in an area adjacent to the claims are estimated to be more than 227,000 t.

Dimension stone is also found 3 km southeast of the Lemac group. These beds are thinner than those in the vicinity of the Lemac group and show local folding.

Diatomaceous earth occurs in several places in the district. Beds are as much as 2.4 m thick on the April Fool claim group, and 2.1 m near the Rainbow Ridge mine. A sample analyzed by Johns-Manville in 1935 showed the diatoms are of wrong types for use as filter aids (Johns-Manville, written commum., 1975).

Since 1950, 720 uranium claims have been located in the Virgin Valley district. They are concentrated in two areas; one, referred to as the McKenney Camp uranium claims, is on rhyolite and has no value as a uranium resource. The second, the Virgin Valley uranium claims, covers an area about 0.4 km wide that extends north from the Virgin Valley Ranch for approximately 1.6 km. Studies show this to be a large low-grade uranium resource.

LONE PINE DISTRICT

The Lone Pine district occupies the southern half of the refuge and extends beyond the southern boundary into Bald Mountain Canyon (fig. 25). Elevations range from 1830 m on the western and eastern study area boundaries to 2192 m at the summit of Yellow Peak. State Highway 34A, from Cedarville to Denio, skirts the district's north side.

The country rock is principally andesite and associated tuffs, with most of the latter altered to a bentonitic clay. Gold and silver prospecting began in 1897 and continued through 1909. The district has had not reported gold or silver production; however, studies indicate it has potential. In 1929 mercury was discovered; soon thereafter, the Antelope claims were located south of the refuge boundary. The Antelope mine produced a small amount of mercury, but assays show the ore is low-grade. A total of 353 claims were located in the district, 80 of which are south of the study area boundary.

In 1954 and 1955 a total of 142 uranium claims were located; however, little activity followed, and the district is now idle.

MINERAL COMMODITIES

Opal, building stone, and uranium are the principal commodities in the Charles Sheldon wilderness study area. Except where noted, national and world data and other technical data for the following section are from U.S. Bureau of Mines Commodity Data Summaries, January 1976, 1978, and Minerals Facts and Problems, 1975.

Gemstones (including precious opal)

Annual domestic gemstone production from 1880 to 1970 constituted from 0.2 to 1.3 percent of the world's total output in terms of value (Jahns, 1975). Opal represented approximately 1 percent of the domestic production in 1970 (Jahns, 1975). Opal represents less than 2 percent of the total production (excluding diamonds and pearls) in the world (Jahns, 1975). In 1976 domestic gemstone production was estimated to be $6.8 million, and apparent consumption, including diamonds, was estimated to be $1,098 million. Estimated imports were $1,622 million, while exports and re-exports were $533 million. United States precious opal deposits occur principally in Nevada, and to lesser extents in Idaho, Oregon, and Washington (Schlegel, 1957). Nearly all imported precious opal comes from Australia Zale's Jewelry Co., Spokane, Washington (oral commun., 1978).

Precious opal's greatest utilizations are in the jewelry industry and as collector's items. Common opal and opalized wood are sometimes cut and polished for ornaments.

Precious opal jewelry has become increasingly popular, and the demand is expected to increase. Synthetic opals are of low quality and of little, if any, commercial importance.

Opal prices vary greatly, according to the matrix color, intensity, and color of opalescence. Prices increase as matrix color darkens and intensity of opalescence increases. Prices per carat also increase with larger cabochons. A transparent opal with intense opalescence may be valued from $10 to $35 for a one-carat cahochon and $30 to $90 per carat for a 10-carat cabochon. A very dark opal with intense opalescenace may be valued from $130 to $4,000 for a one-carat cabochon and $400 to $7,200 per carat for a 10-carat cabochon (Jahns, 1975).

Although opal is mined in several places, the Virgin Valley district's most productive mines are the Rainbow Ridge, Royal Peacock, and Virgin Opal (Bonanza).

Building stone

Dimension stone's major uses are: rough blocks, monuments, building stone, curbing, and rubble. Estimated domestic production in 1977, was 1.3 million t valued at $104 million. Of the total, 41 percent was granite, 30 percent limestone, and 19 percent sandstone. U.S. demand for dimension stone is not expected to grow through 1985. The estimated average price in 1977 was $86/t.

During production years, tuffaceous sandstone was quarried from the north end of Virgin Valley and reportedly sold for $66/t at the quarry site (oral commun., Bob Wegman, 1976).

Uranium

In 1977 primary U.S. uranium demand for nuclear fuels was estimated to have been 11,200 t U_3O_8. An additional 270 t, from depleted uranium stocks, were consumed in non-nuclear uses such as ballast, counterweights, radiation shielding, alloys, catalysts, glass colorant, and electrical components. Recoverable mine production was 12,700 t U_3O_8. Imports of uranium concentrates and other compounds for consumption totaled approximately 3,600 t, and came primarily from Canada. United States reserves area estimated to be 620,000 t of U_3O_8 at $66/kg. In 1977, the average price of U_3O_8 was $44/kg. At year end, the spot market price was about $93/kg.

To meet the requirements of commercial power reactors during the next decade, domestic U_3O_8 production is expected to continue its rapid growth. Demand is anticipated to increase at an annual rate of 15 percent through 1985.

The average grade of ore mined by 120 operations in 1975 was 0.18 percent U_3O_8.

Uranium claims are situated sporadically throughout the range and refuge. The main group covers an area about 1.6 km wide and 3.2 km long extending north from the Virgin Valley Ranch.

PREVIOUS STUDIES

Most of the studies in the area were limited in scope. Mirriam (1910) desribed the geology of Virgin Valley and Thousand Creek Formations. Frock (1963) and Wendell (1970) described the stratigraphy and structure of the Virgin Valley-McGee Mountain-Thousand Creek area. Ross (1941), Bailey (1944), and Holmes (1965) discussed mercury potential in the Bald Mountain area, Lone Pine districts. Staatz (1951) conducted a limited reconnaissance of the uranium potential in Virgin Valley, and Stager (1959) discussed a manganese occurrence near Virgin Creek.

PRESENT STUDIES

Methods of evaluation

Courthouse records and mineral reports were used to determine the historical significance of the mining districts, and sites of claims and mineral deposits. Past and present owners of mineral properties were contacted; historical property data and production records were obtained where available. Permission to examine the properties and publish data was sought from owners to active claims. Most of the owners denied permission to examine their properties. The descriptions of properties for which permission was not granted are taken from earlier reports and, therefore, are not supported or augmented by Bureau of Mines field examinations.

All mines, prospects, and claims were sought in the field. Where permitted, the properties were examined, and where warranted, sampled and mapped.

Resources have been classified according to the following definitions adopted by the U.S. Bureau of Mines and U.S. Geological Survey (U.S. Bureau of Mines and U.S. Geological Survey, 1976).

Resource.--A concentration of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

Reserve.--That portion of the identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term ore is used for reserves of some minerals.

Indicated.--Reserves or resources for which tonnage and grade are computed partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout.

Inferred.--Reserves or resources for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition, of which there is geologic evidence; this evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geologic evidence of their presence. Estimates of inferred reserves or resources should include a statement of the specific limits within which the inferred material may lie.

Paramarginal.--The portion of Subeconomic Resources that (1) borders on being economically producible or (2) is not commercially available solely because of legal or political circumstances.

Submarginal.--The portion of Subeconomic Resources which would require a substantially higher price (more than 1.5 times the price at the time of determination) or a major cost-reducing advance in technology.

Sampling and analytical methods

Four hundred three lode samples ranging from 2.2 to 4.5 kg were collected during field evaluations. Four types were taken: chip, a series of continuous rock chips across or along exposure; random chip, a collection of rock chips from an exposure; grab, an unselected assortment of rock pieces from a rock pile or exposure; and select, hand-picked material of the highest grade rock available. Most of the lode samples were fire assayed to determine their gold and silver content. Samples containing visible metallic minerals were analyzed by atomic absorption, colorimetric, or X-ray fluorescence methods. At least one sample from each mineralized structure on a property was analyzed by semiquantitative spectrographic methods. If anomalous amounts of economic elements were detected in a sample by spectrography, the sample was further analyzed by more accurate means. All were checked for the presence of radioactive and fluorescent minerals.

Claims located for uranium were checked for radioactivity with a hand-held scintillation counter. Readings were recorded in milliroentgens per hour (mR/hr).

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to claim holders, property owners, and local residents for their cooperation. Special acknowledgment is due Harry W. Wilson and Keith Hodson for their historical data on precious opal; and to Henry John, for his historical sketch of the area.

MINES AND PROSPECTS

Described in alphabetical order are the 41 mines, prospects, and claimed areas within or immediately adjacent to the study area that were examined.

Name: Antelope Nos. 1-18 (Lodestar Nos. 1-60)

Index Map No.: Plate 5, No. 1

Location: Secs. 22, 23, and 24, T. 45 N., R. 21 E., a short distance outside the south boundary of refuge

Elevation: 1770 to 1950 m

Access: By jeep road 10 km southwest from refuge headquarters.

History: The Antelope claims located by Curtis Mathews and W. S. Miller in December 1929, marked the first reported discovery of mercury in the Lone Pine mining district. Little exploratory work was done until the Colton Log and Lumber Co. took a bond on the property in 1939 (Bailey and Phoenix, 1944). Reportedly they recovered a small amount of mercury from a 10-pipe retort. During 1955 and 1956, a batch-type furnace plant was installed, and in 1958 development of alluvial material was undertaken (U.S. Bur. Mines, 1965). Little work has since been done on the property.

In 1969 the Lodestar Nos. 1-60 were located by Frank Margrave. The claims reported lie slightly south of the Charles Sheldon Antelope Refuge and probably overlap the Antelope group.

Previous production: Reportedly a small amount of mercury has been produced (Bailey and Phoenix, 1944).

Geology of deposit: The country rock is northerly-striking, easterly-dipping andesite flows, with associated tuffs and agglomerates. The andesite is red to black and fine-grained. The tuffs are light gray and contain a few layers of conglomerate. Andesite in the southern part of the area is overlain by a basalt flow 6 to 15 m thick. Mineralized rock is restricted to a series of steeply-dipping, northwest-trending shear zones, and to a lesser extent, alluvial material (Ross, 1941). Structures reported by Ross (1941) are obscured by colluvium.

Development: One caved, inclined shaft, reported to have been 21 m deep (U.S. Bur. Mines, 1965), 113 pits, and 39 trenches were observed (fig. 26). Nearly all workings are caved. Most excavation was done by bulldozer.

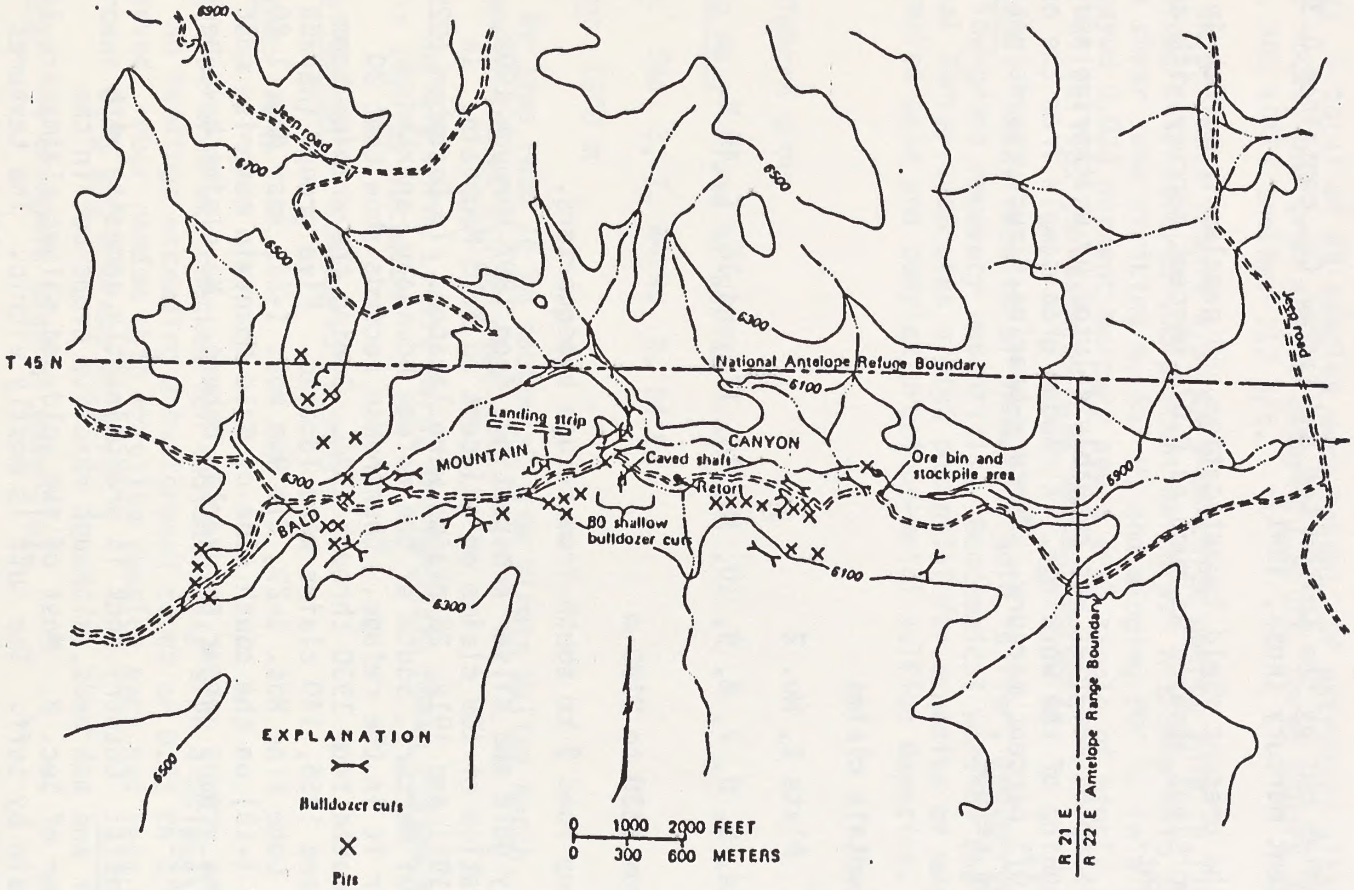

6900
Jeep road
6700
6500
6300
T 45 N
National Antelope Refuge Boundary
6100
Landing strip
MOUNTAIN
CANYON
Caved shaft
Retort
Ore bin and
stockpile area
6900
Jeep road
BALD
80 shallow
bulldozer cuts
6300
6100
6500
EXPLANATION
Bulldozer cuts
Pits
0 1000 2000 FEET
0 300 600 METERS
R 21 E
R 22 E
Antelope Range Boundary

Figure 26.--Workings, Antelope group.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Sampling: In 1940 the U.S. Geological Survey cut four samples across seams 48, 36, 15, and 122, 91, 38, 25 cm thick that assayed 0.29, 0.07, 0.18, and 0.70 percent mercury, respectively (Ross, 1941).

Four samples cut by the Colton Log and Lumber Co. contained 0.35, 0.33, and 0.075 percent mercury (Ross, 1941).

During the present field investigation, 59 samples from rock in place and dumps of workings assayed as much as 0.073 percent mercury with an average of 0.005 percent.

Conclusions: Sampled material was probably diluted by weathering and resultant sloughing of the workings. A random grab sample from the ore bin assayed 0.073 percent mercury. Mercury-bearing structures do not extend into the refuge.

Name: Bald Mountain claims

Index Map No.: Plate 5, No. 2

Location: Secs. 5, 6, 7, 8, 9, 10, 15, 16, 17, and 18, T. 45 N., R. 21 E.

Elevation: From 1830 to 2190 m

Access: By jeep road 3 km south from refuge headquarters.

History: Early gold and silver prospecting, from 1897 through 1909, led to the location of 109 claims on adjacent to Bald Mountain. In the two years 1911 and 1918, 25 claims were located. In December 1929, the discovery of mercury, south of the refuge boundary, sparked exploration for it in the refuge. Courthouse records show that 30 claims were located from 1930 through 1941. During the uranium boom years of 1954 and 1955, 140 claims were located. Five groups (Nevada Guy Nos. 1-43, Lone Pine Nos. 1-29, Jim Bum Nos. 1-22, Amar Nos. 1-20, and Hades Nos. 1-13) on the south side of Bald Mountain comprise most of the claims. Some groups appear to overlap others. No claims have been located since 1955.

Geology of deposit: Country rock is predominantly andesite with associated tuff and ash beds, although rhyolite crops out in the southwest corner of Sec. 8. Most of the gold and silver claims are in an area underlain by tuff. The tuff is mostly vitric. The textures grade from very fine to coarse and sugary; some are welded. Colors are cream, light green, yellow, pink to purple, brown, and red. Much of the tuff has altered to bentonitic clay. Most of the uranium claims are underlain by fine-grained, dark-colored andesite.

Development: Four caved adits, 2 shafts, 5 cuts, 36 pits, and 60 trenches were found in the area (fig. 27). Most of the workings are caved.

Sampling: A total of 86 samples were taken. Of extremely altered volcanic rocks, one grab sample assayed 1.4 g/t, three others assayed 0.3 g/t, and still another 113 g/t.

A chip sample from a 1.3- to 5-cm-thick quartz vein in light purple to brown welded tuff assayed .06 percent mercury. A 1.34-m chip sample taken across a shear zone striking N. 55' W. and dipping 80' S. in a purple welded tuff assayed 0.023 percent mercury and a grab sample of highly altered green and pink silicified ash assayed 0.02 percent mercury.

Conclusions: Assay results of anomalous gold, silver, and mercury suggest low-grade recovery potentials. Geochemical work by the U.S. Geological Survey indicates a high potential for deposits of mercury and for concealed base and complex precious-metal sulfide deposits.

Name: Bighorn group

Index Map No.: Plate 5, No. 13

Location: Sec. 2, T. 44 N., R. 24 E.

Elevation: 1830 m

Access: By jeep road 16 km southwest from Virgin Valley Ranch, then by cross-country travel 1.6 km east

History: The Big Horn, Little Horn, and Mountain Sheep claims were located in 1960 by Vottero.

Geology of deposit: Weathered rhyolite

Development: None

Sampling: The area was checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.02 to 0.03 mR/hr were observed. Four random chip rhyolite samples each had less than 0.001 percent U_3O_8 and a trace silver.

Conclusions: No economic mineral potential.

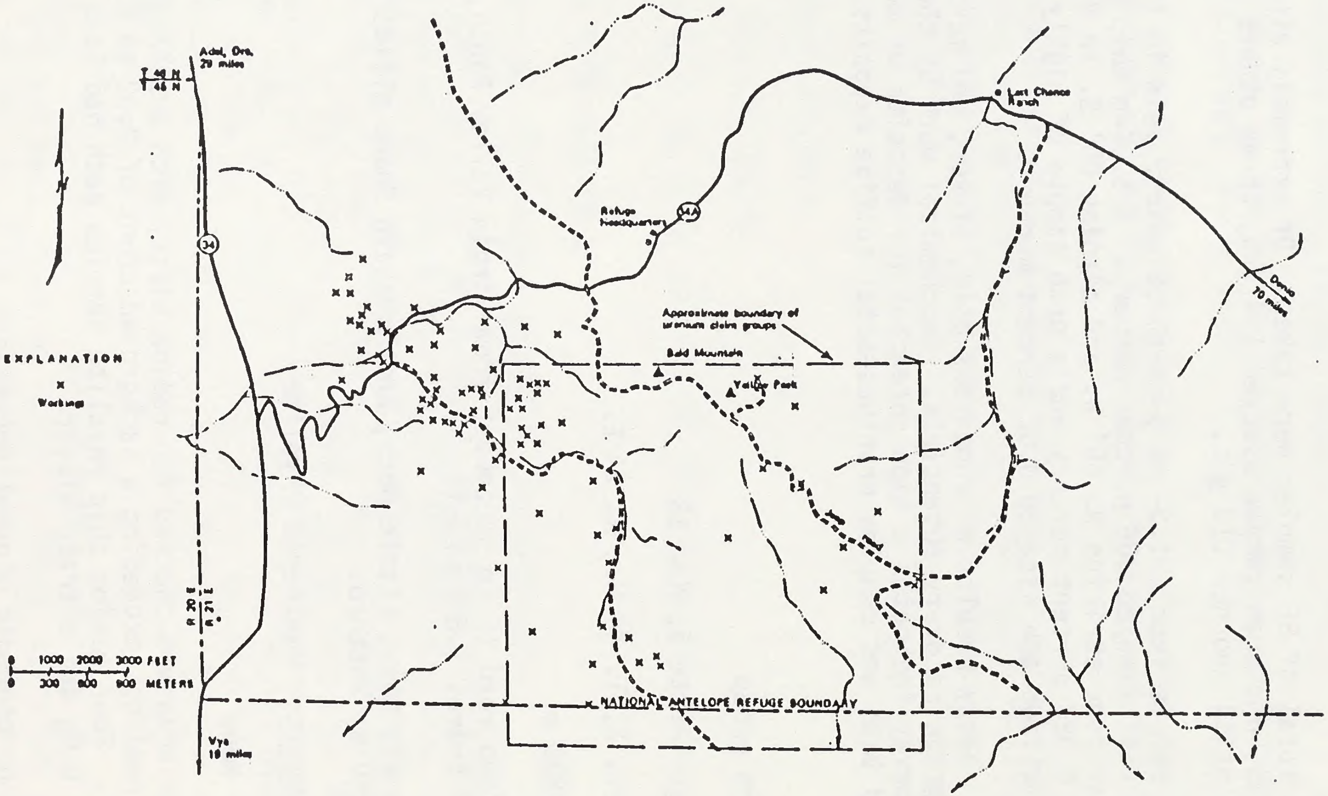

N
Adel, Ore.
29 miles
T 46 N
T 45 N
34
EXPLANATION
Workings
0 1000 2000 3000 FEET
0 300 600 900 METERS
R 20 E
R 21 E
Vya
18 miles
Refuge Headquarters
34A
Last Chance Ranch
Denio
70 miles
Approximate boundary of uranium claim groups
Bald Mountain
Yellow Peak
Jeep Road
NATIONAL ANTELOPE REFUGE BOUNDARY

Figure 27.--Workings, Bald Mountain claims.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Name: Blue Dragon Nos. 1-3

Index Map No.: Plate 5, No. 35

Location: Sec. 24, T. 44 N., R. 24-1/2 E.

Elevation: 1710 to 1800 m

Access: By jeep road 26 km southwest from Virgin Valley Ranch

History: The claims were located by Vincent Palmer in 1968 for mercury.

Geology of deposit: The area is underlain by ash beds that have been partially altered to montmorillonite clay. A silicified breccia zone crops out over a 183 m square area. The zone has angular fragments of cream- to pink-colored ash in a matrix of clear to light-pink silica. Mercury minerals are scarce.

Development: One shaft, 13.4 m deep, three bulldozer cuts, one pit, four trenches, and one caved adit or trench.

Sampling: Nine samples from rock in place and from workings dumps assayed a trace of gold, and as much as 10 g/t and 0.006 percent mercury.

Conclusions: Low mineral potential.

Name: Charline Nos. 1 and 2

Index Map No.: Plate 5, No. 5

Location: Secs. 14 and 15, T. 46 N., R. 23 E.

Elevation: 2012 m

Access: By Highway 34A, 10 km west from the junction with Highway 8A, then by cross-country travel 1.6 km north

History: Located by Charline Brown in 1956

Geology of deposit: Gray to reddish-brown banded rhyolite

Development: None

Sampling: The area was checked for radioactivity with a scintillation counter. No readings exceeding the background count of 0.025 to 0.03 mR/hr were observed. Three random chip samples from rhyolite outcrops had no anomalous metallic content.

Conclusions: No economic mineral potential.

Name: Crater group

Index Map No.: Plate 5, No. 36

Location: Secs. 15, 16, and 22, T. 44 N., R. 24 E.

Elevation: 2110 to 2170 m

Access: By jeep road 24 km southwest from Virgin Valley Ranch

History: Thirty-one claims were staked in 1954 by Harry W. Wilson, and others.

Geology of deposit: Iron-oxide-stained, light-gray rhyolite

Development: Twenty discovery pits observed

Sampling: Discovery pits were checked for radioactivity with a scintillation counter. Background readings of 0.04 to 0.045 mR/hr were observed. One small area near the summit of Blowout Mountain had a reading of 0.07 mR/hr. Sixteen samples of rhyolite and residual soil each contained a trace silver and less than 0.001 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Echo group

Index Map No.: Plate 5, No. 6

Location: W1/2 sec. 31, T. 46 N., R. 24 E.

Elevation: 1860 m

Access: By State Highway 8A, 6.4 km from junction with State Highway 140.

History: Twelve mining claims were located in 1955 by S and S Exploration Co.

Geology of deposit: The area is underlain by rhyolite and recent alluvium. No mineralized structures were observed.

Development: Eight shallow bulldozer cuts in alluvium

Sampling: All bulldozer cuts and outcrops were checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.03 to 0.035 mR/hr were observed. Four samples from bulldozer cuts and six from rhyolite outcrops assayed a trace silver and less than 0.001 percent U_3O_8 each.

Conclusions: No economic mineral potential.

Name: Eddy group

Onwer: Charles L. Eddy and others

Index Map No.: Plate 5, No. 23

Location: Secs. 5 and 8, T. 45 N., R. 26 E.

Elevation: 1555 m

Access: By Virgin Valley road 8 km south from junction with State Highway 140, then by good dirt road 0.8 km northwest

History: The group consists of 21 claims: West Gem Hill, Mayday, Bluebird, Richard, Patrick, Crazy Indian, Lil Abner, Daisy Mae, No. 2 Opal, Hidden Valley, Lu Lu, Sparkle Plenty, Windfall, Marvelous, Lorrie Lee, East Gem Hill, Nancy's Nightmare, Sun Valley, Evening Star, Opal Valley, and New Moon. One claim was located in 1948, the others 1969 through 1974.

Previous production: Mr. Eddy stated that some precious opal has been produced but did not specify the amount.

Geology of deposit: An opal-bearing horizon is in slump blocks of bedded volcanic tuffs, ash, and tuffaceous sandstone and siltstone. The horizon is bentonitic, greenish in color, and contains wood fragments and pebbles. In places, it is 1.8 m thick. Sediments range in dip from flat-lying to as much as 30 degrees. The opal-bearing horizon is difficult to trace because it is slumped and tilted.

Development: Approximately 70 pits and bulldozer trenches were observed. Some trenches are several hundred feet long (fig. 28).

Sampling: Sampling consisted of digging into exposed beds and observing the presence or absence of indicators of precious opal. Common opal was observed at numerous places.

Conclusions: The likelihood of additional precious opal is high.

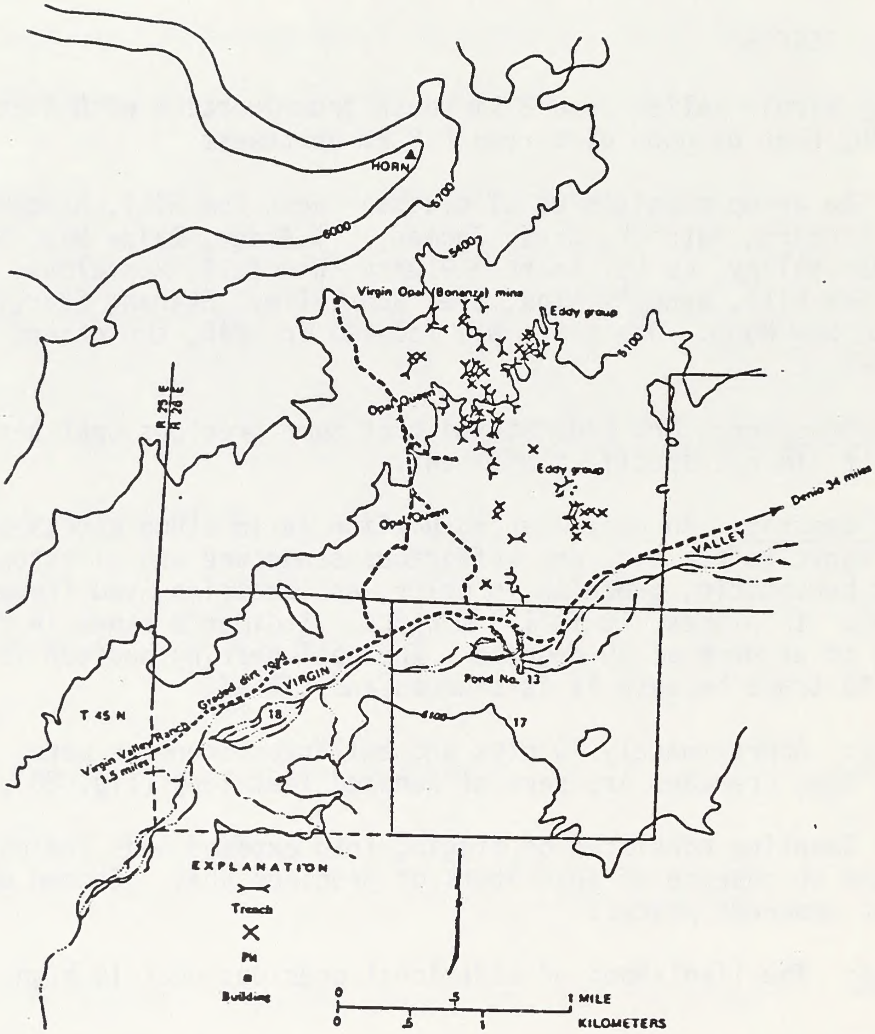

HORN
6700
6000
5400
Virgin Opal (Bonanza) mine
Eddy group
5100
R 25 E
R 26 E
Opal Queen
Eddy group
Opal Queen
Denio 34 miles
VALLEY
Pond No. 13
VIRGIN
Graded dirt road
Virgin Valley Ranch 1.5 miles
T 45 N
18
17
5100
EXPLANATION
Trench
Pit
Building
0
.5
1 MILE
0
.5
1
KILOMETERS

Figure 28.--Workings, Eddy group.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Name: Fortune group, Uranium King, and Lucky Jack

Index Map No.: Plate 5, No. 18

Location: Secs. 29, 31, and 32, T. 46 N., R. 27 E.

Elevation: 1330 to 1420 m

Access: By State Highway 140, 37 km west from Denio

History: The Fortune group, consisting of 20 claims, was located in 1955 by Charles Baker. The Uranium King and Lucky Jack claims were located in 1955 by Jack Neal and Roy Clifton.

Geology of deposits: Alluvium containing abundant rhyolite and basalt cobbles overlies tuffaceous sediments. Rhyolite crops out on the south end of the claim block.

Development: Approximately 45 bulldozer cuts

Sampling: All workings were checked for radioactivity with a scintillation counter. No reading exceeding a background count of 0.015 to 0.03 mR/hr was observed. Twelve samples from bulldozer cuts had no anomalous metallic content.

Conclusions: No economic mineral potential.

Name: Golden Cash, Jackpot, Buried Treasure, and Golden Horde

Index Map No.: Plate 5, No. 39

Location: Sec. 36, T. 44 N., R. 24 E.

Elevation: 1890 m

Access: By jeep road 16 km south from Virgin Valley Ranch.

History: Carl A. Stone and Dorothy J. Alford each located two claims in 1954.

Geology of deposit: Gray to green rhyolite

Development: None

Sampling: The area was checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.025 to 0.035 mR/hr were observed. Four random chip samples of rhyolite each contained a trace gold and silver and less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Goodwill

Index Map No.: Plate 5, No. 20

Location: Sec. 2, T. 45 N., R. 26 E.

Elevation: 1490 m

Access: By dirt road 1.6 km south from Duffurrena Sub-headquarters.

History: The claim was located as a "mercury and hydrothermal lode" in 1974 by Harry W. Wilson.

Geology of deposit: The claim is underlain by beds of ash, ash partially altered to montmorillonite clay, and tuffaceous sandstone striking N. 10' W. and dipping 1' to 5' SW. The ash bed contains numerous geodes.

Development: Five pits

Sampling: One sample was taken from the pits and contained 20 ppm mercury.

Conclusions: The claim has no economic potential for mercury. The geodes may have some economic value. The tuffaceous sandstone is relatively unfractured and its thickness, cleavability, and horizontal dimensions are such that it may be suitable for dimension stone.

Name: Grubstake Nos. 1-4

Index Map No.: Plate 5, No. 29

Location: Secs. 22, 26, and 27, T. 45 N., R. 25 E., south of Mud Spring Canyon, 1.6 to 3.2 km west of Virgin Valley Ranch

Elevation: 1600 to 1720 m

Access: By dirt road 1.6 km west from Virgin Valley Ranch

History: The Grubstake group was located in 1955 by Grace Cummings and Meed Cooley.

Geology of deposit: Colluvium overlying gray to reddish rhyolite bedrock

Development: Sixteen bulldozer cuts in colluvium. Most are shallow, range from 6 to 107 m in length, and are along the north side of the road over a distance of about 2.4 km

Sampling: All workings were checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.03 to 0.06 mR/hr were observed. Five grab samples of soil and rock from the bulldozer cuts and one chip sample of rhyolite assayed no anomalous metallic content.

Conclusions: No economic mineral potential.

Name: Hope Group

Index Map No.: Plate 5, No. 30

Location: Sec. 21 T. 45 N., R. 25 E.

Elevation: 1798 m

Access: By jeep road 6 km west from Virgin Valley Ranch

History: Thirty-five claims were located by E. Plaskett in 1956.

Geology of deposit: Gray to reddish-brown banded rhyolite and recent alluvium

Development: Thirteen shallow bulldozer cuts in alluvium along the jeep road

Sampling: Bulldozer cuts and rhyolite outcrops were checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.025 to 0.03 mR/hr were observed. Ten samples of alluvium and rhyolite assayed no anomalous metallic content.

Conclusions: No economic mineral potential.

Name: Kim Nos. 1-9

Index Map No.: Plate 5, No. 14

Location: Sec. 23, T. 45 N., R. 24 E.

Elevation: 1830 to 1840 m

Access: By State Highway 8A, 18 km south from junction with State Highway 140, then by dirt road 8 km east

History: The claims were located September 1955 by Kenneth Arnold.

Geology of deposit: Basalt cap rock over rhyolite breccia and tuff

Development: Five shallow bulldozer cuts

Sampling: Bulldozer cuts were checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.02 to 0.04 mR/hr were observed. Five samples from bulldozer cuts each contained a trace gold and silver and less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Ladd and Shepardson's group

Index Map No.: Plate 5, No. 26

Location: Secs. 24 and 25, T. 45 N., R. 26 E.

Elevation: 1520 to 1670 m

Access: By dirt road 8 km south from Duffurrena Sub-headquarters.

History: A group of 12 claims was located in 1956 by Ladd and Shepardson.

Geology of deposit: Alluvium overlies rhyolite and light gray, green, and yellow welded tuffs. No mineralized structures were observed.

Development: Three pits, two bulldozer cuts, and three roads or cuts totaling about 3 km in length.

Sampling: Five samples taken from rock in place and from dumps of bulldozer cuts assayed only a trace uranium.

Conclusions: No economic mineral potential.

Name: Lemac Nos. 1-5

Owner: Tom Conner

Index Map No.: Plate 5, No. 19

Location: Sec. 2, T. 45 N., R. 26 E.

Elevation: 1478 m

Access: By Virgin Valley road 3 km south from junction with State Highway 140.

History: Stone was first quarried from the deposit in the early 1870's; it was used in the contruction of homesteads in northwestern Nevada. Prior to 1952, Mr. Turner held the claims (personal commun., Henry John, 1976); in 1952, Bob Wegman and his brothers, William and Theron started production at the site. A cable saw capable of cutting 82 t without being moved, three mud saws for slabbing, and a guillotine crusher were installed. The Wegmans worked the quarry for 15 years before abandoning the claims (oral commun., Bob Wegman, 1976). The claims were relocated in 1970 by Mike Lee, and acquired in 1972 by Tom Connors, the present owner (personal commun., Henry John, 1976).

Previous production: The only recorded production was that of Wegman's. Approximately 50 percent of the stone mined was suitable for shipping. During 15 years of operation, about 16,000 t were shipped to outlets from as far away as Spokane, Washington, and southern Nevada. At the quarry site stone sold for $66/t (oral commun., Bob Wegman, 1976).

Geology of deposit: Permission for the Bureau of Mines to examine the claims was not received. According to Wendell (1969), "One of the flaggy volcanic siltstone units within the Red Member of the Virgin Valley Formation was commercially quarried for ornamental building stone until 1967. The unit is 5 to 6 m thick in the vicinity of the quarry and thins rapidly in all directions."

Outside the claim boundaries, the flaggy siltstone unit ranges from 0.5 to 0.9 m thick, averaging 0.8 m thick and underlies at least 53 h north and northwest of the quarry. The unit is essentially flat lying, but locally dips as much as 8' both northwest and southeast. The siltstone beyong the claim boundaries is too thin and broken for use as quality ornamental stone.

Development: A quarry which appears to be 61 by 122 m

Conclusions: Probably, under favorable economic conditions, production could be resumed.

Name: Lucky Four

Index Map No.: Plate 5, No. 17

Location: Sec. 33, T. 47 N., R. 26 E.

Elevation: 1710 m

Access: By State Highway 140, 43 km west from Denio, then by cross-country travel 6 km northwest.

History: One 32.4-h placer claim was located by Claude Noble in 1951.

Geology of deposit: The claim is underlain by recent alluvium and basalt. No mineralized structures were observed.

Development: None

Sampling: One sample assayed a trace silver and less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Lucky Horshoe group

Index Map No.: Plate 5, No. 38

Location: Sec. 6, T. 43 N., R. 25 E.; Sec. 31, T. 44 N., R. 25 E., and Sec. 36, T. 44 N., R. 24-1/2 E.

Elevation: 1905 to 2045 m

Access: By jeep road 13 km south from Virgin Valley Ranch

History: Fourteen claims were located in 1955 by P. B. Meyers, J. Meyers, W. W. Ware, and G. Kendricks.

Geology of deposit: Gray to green rhyolite

Development: None

Sampling: The area was checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.025 to 0.030 mR/hr were observed. Ten random chip samples of rhyolite each contained a trace gold and silver and less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Lucky Jim Nos. 1-8 and Apex

Index Map No.: Plate 5, No. 11

Location: Sec. 32, T. 45 N., R. 24 E.

Elevation: 1900 m

Access: By State Highway 8A, 19 km south from junction with State Highway 140, then by jeep road 3 km east

History: The Lucky Jim group was located in 1955 by Ralph Peterson, and the Apex in 1955 by Gus Pearson.

Geology of deposit: Colluvium and alluvium over rhyolite bedrock

Development: Four bulldozer pits in alluvium

Sampling: All bulldozer pits were checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.015 to 0.03 mR/hr were observed. Four samples of soil from bulldozer pits each contained a trace gold and silver and less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Lucky Strike

Index Map No.: Plate 5, No. 33

Location: Sec. 12, T. 44 N., R. 24-1/2 E.

Elevation: 1920 m

Access: By State Highway 8A, 19 km south from junction with State Highway 140, then by jeep road 14 km east.

History: Located in 1949 by Mary Lamb and Vincent Marconi.

Geology of deposit: The claim is underlain by ash beds. A 4.9-m wide fault zone trending N. 74' W. and intermittently exposed for 97.5 m contains brecciated ash layers in a siliceous matrix.

Development: A trench 7.6 m wide, 33.5 m long, and 3.7 m deep is the principal working. Eight other small trenches and pits are on the zone.

Sampling: Two chip samples across the zone each contained a trace gold and 3.4 g/t of silver.

Conclusions: No economic mineral potential.

Name: McKenney Camp uranium claims

Index Map No.: Plate 5, No. 15

Location: Secs. 15, 21, 22, 23, 27, and 28, T. 46 N., R. 25 E.

Elevation: 1550 to 1680 m

Access: By State Highway 140, 62 km west of Denio

History: The area contains 116 mining claims located from 1955 through 1969 by various persons. Many are relocations.

Geology of deposit: The claims are underlain by recent alluvium and gray to dark purplish rhyolite. No mineralized structures were observed.

Development: Fifteen shallow bulldozer cuts in alluvium

Sampling: The area was checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.02 to 0.04 mR/hr were observed. Thirty-two samples from rock in place and bulldozer cuts contained no more than a trace gold and silver and less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Mesa

Index Map No.: Plate 5, No. 31

Location: Sec. 31, T. 45 N., R. 26 E.

Elevation: 1890 m

Access: By jeep road 3 km southeast from Virgin Valley Ranch

History: Located in 1953 by MacDonald

Geology of deposit: Flay-lying basalt caps volcanic sediments

Development: Shallow bulldozer cuts in residual soil overlying the basalt

Sampling: One bulldozer cut grab sample had no anomalous metallic content.

Conclusions: No economic mineral potential.

Name: Meyer group mine

Onwer: John and Virgie Meyer

Index Map No.: Plate 5, No. 24

Location: Sec. 17, T. 45 N., R. 26 E.

Elevation: 1500 to 1570 m

Access: By Virgin Valley road 4 miles (6 km) south from Duffurrena Sub-headquarters

History: The group consists of five claims. The Becky, Mucket, and White Hills claims were located in the summer of 1954, and the Moon Walk in July 1969. Former owners of the Black Hope quit claimed to Meyer in 1971. Meyer leased the Becky and Mucket claims to Opals Incorporated from about 1969 to 1971.

Production: Owner's income from the Becky and Mucket claims during 1969 to 1971 was approximately $3,500; $1,500 of which was from leasing and $2,000 from opals produced by the lessee. The $2,000 represents 5 percent of the total opal value.

The owners themselves mined $2,000 worth of opal from the Black Hope, White Hills, and Moon Walk claims.

Total opal value produced from the Meyer group is estimated to be $42,000.

Geology of deposit: Nearly horizontally-bedded lacustrine sediments of volcanic tuff, ash, and ashy sandstone and siltstone have occasional layers of gypsum and pieces of wood in various stages of petrification. Tuff layers exposed to weathering are altered to montmorillonite. Petrified wood and small fragments of precious opal were found in the tuff exposed by the largest bulldozer cut on the Moon Walk claim. The opal-bearing tuff horizon is 3 m thick in places. A well-exposed contact between tuff and an overlying bed of ash has an apparent dip of 3' N.

Development: Thirteen bulldozer cuts and one pit was observed (fig. 29). A small wooden storage shed is on the White Hills claim.

Sampling: Sampling consisted of digging into the exposed beds and observing the presence or absence of indicators of precious opal. Small fragments of precious opal were observed.

Conclusions: The Meyer claims have a precious opal potential. About 12 h, underlain by the opal-bearing horizon, are minable. This is based on a strike length of 1,830 m and an economic width limit of 60 m. Beyond 60 m, the stripping ratio would be excessive.

Name: Obsidian group, Columbia and Loise

Index Map No.: Plate 5, No. 9

Location: Secs. 2 and 11, T. 44 N., R. 23 E.

Elevation: 1830 to 1950 m

Access: By State Highway 8A, 22 km south from junction with State Highway 140

History: The Obsidian group consists of eight claims located in 1955 by Carl H. Ripattee and H. E. Alloway. The Columbia and Loise claims were located in 1956 by Carol J. Hicks.

Geology of deposit: Recent alluvium overlies gray rhyolite with feldspar phenocrysts. No mineralized structures were observed.

Development: One shallow bulldozer cut in alluvium

Sampling: The area was checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.02 to 0.03 mR/hr were observed. Ten samples of alluvium and rhyolite had traces of gold and silver, and less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

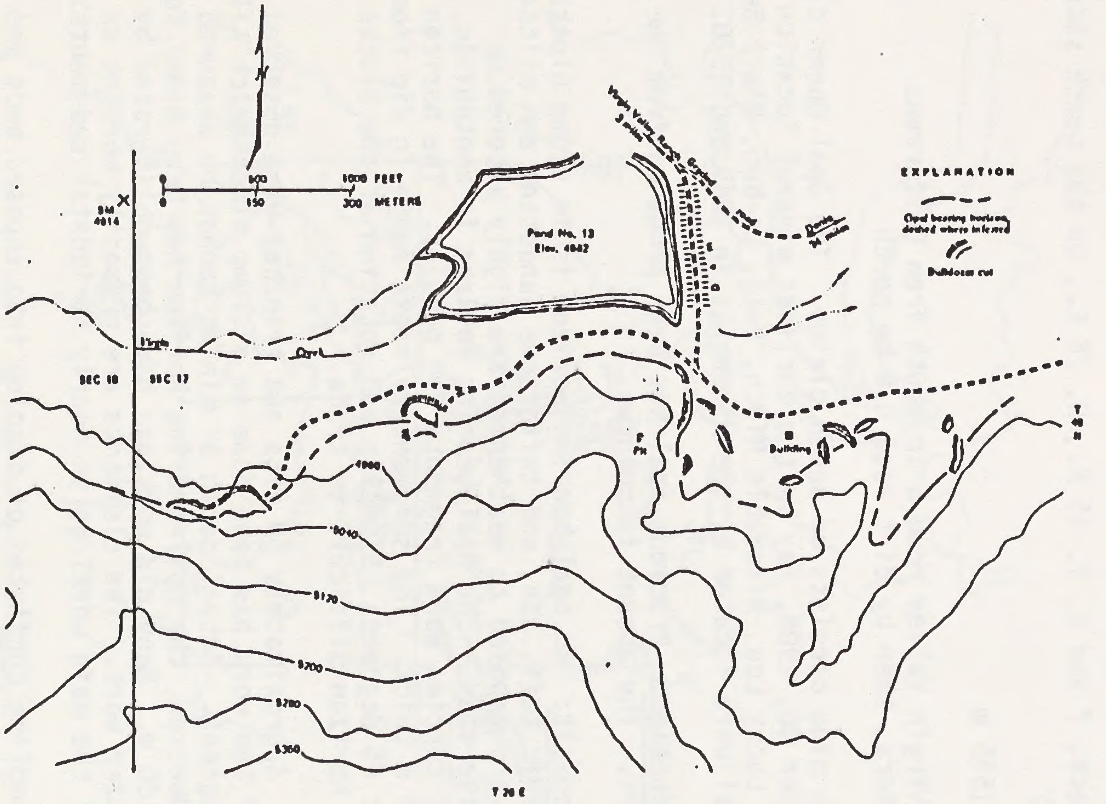

EXPLANATION
Opal bearing horizon, dashed where inferred
Bulldozer cut
Pond No. 13
Elev. 4862
Virgin Valley Ranch
3 miles
Graded road
Denio
34 miles
E
D
0
500
1000 FEET
0
150
300 METERS
N
BM
4814
SEC 18
SEC 17
Virgin
Creek
Pit
Building
4960
5040
5120
5200
5280
5360
T 26 E
T 45 N

Figure 29.--Meyer group mine.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Name: Opal Queen group mine

Owner: Ed and Louise Mitchell

Index Map No.: Plate 5, No.22

Location: Secs. 7 and 8, T. 45 N., R. 26 E., on the north side of Virgin Valley

Elevation: 1555 m

Access: By Virgin Valley road 6 km south from Duffurrena Sub-headquarters, then by dirt road 0.8 km north

History: The mine consists of seven claims. The Opal Queen claim, located October 30, 1908, may be the earliest mineral location in Virgin Valley. The Lucky Lou, Miserable Mitch, Bell, Le-Bob, Black Beauty, and Beautiful Opal were located by the Mitchells in 1969 and 1970.

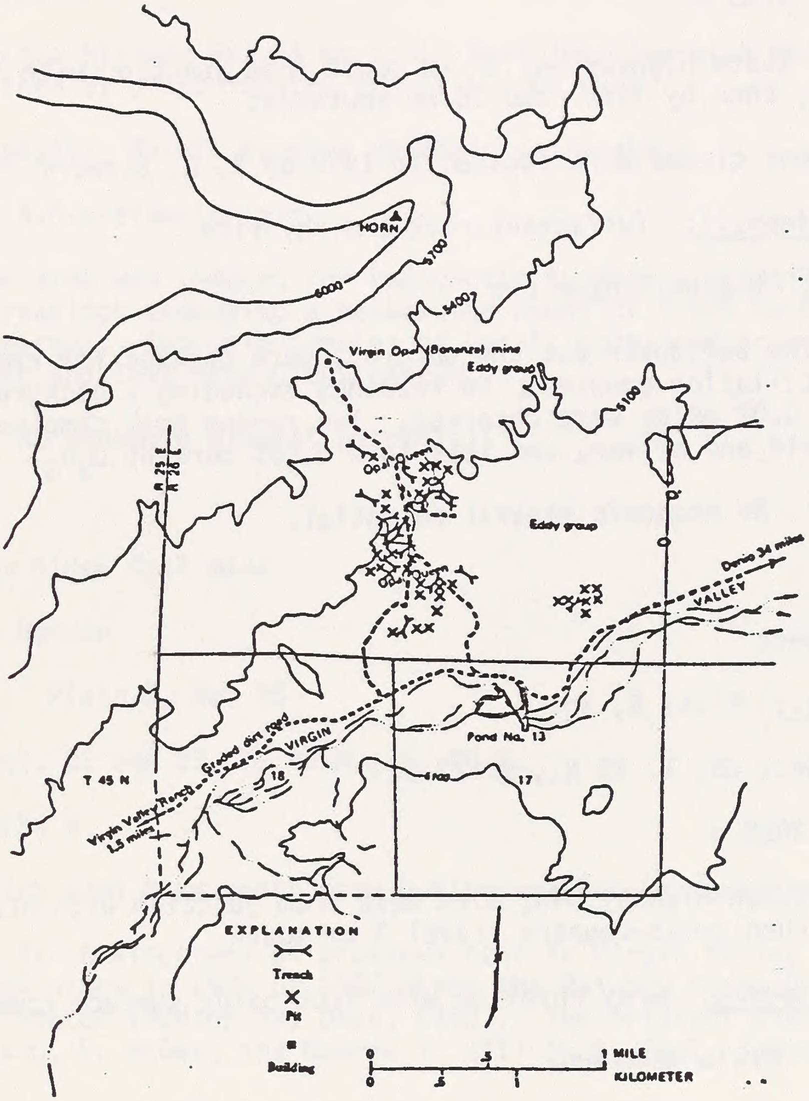
Precious production: Precious opal has been produced from the property for many years. The amount is unknown.

Geology of deposit: An opal-bearing horizon is in slump blocks of bedded, volcanic tuff, ash, and tuffaceous sandstone and siltstone. Some tuff layers exposed to weathering are highly altered to montmorillonite clay. The opal-bearing horizon is bentonitic, greenish in color, and carries wood fragments and pebbles. The horizon is sometimes 1.8 m thick. The sedimentary rocks range in dip from flat lying to 45 degrees. Slumping and rotation of the blocks make the opal-bearing horizon difficult to trace.

Development: Approximately 50 pits and trenches were observed (fig. 30). Most of the work has been done on a slump block which tilts as much as 45 degrees. Actual depth of mining cannot be measured because of caving. However, the opal-bearing horizon has been mined for a distance of 180 m. Many old workings have been obliterated by more recent bulldozer work. The claimants are presently working on an area 76 m south of the main workings in nearly horizontal sediments.

Sampling: Sampling consisted of digging into exposed beds and observing the presence or absence of indicators of precious opal. At the time of examination, the claimants removed several precious opals. One specimen of the black variety measured about 5 cm by 2.5 cm by 3.8 cm and was valued at several hundred dollars.

Conclusions: The likelihood of additional precious opal is high. The area presently being mined and developed covers 0.4 to 0.8 h.



HORN
6000
5700
5400
Virgin Opal (Bonanza) mine
Eddy group
5100
R 25 E
R 26 E
Opal Queen
Opal Queen
Eddy group
Denio 34 miles
VALLEY
Pond No. 13
Graded dirt road
VIRGIN
T 45 N
18
5100
17
Virgin Valley Ranch 2.5 miles
EXPLANATION
Trench
Pit
Building
0
.5
1 MILE
0
.5
1
KILOMETER

Figure 30.--Workings, Opal Queen group mine.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Name: Pretty Rock group

Index Map No.: Plate 5, No. 41

Location: Sec. 28, T. 43 N., R. 23 E.

Elevation: 1783 m

Access: By State Highway 8A, 27 km south from junction with State Highway 140, then by dirt road 18 km southeast

History: Four claims were located in 1955 by B. D. Steward

Geology of deposit: Tuffaceous rock and rhyolite

Development: One bulldozer cut

Sampling: The bulldozer cut and outcrops were checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.015 ti 0.02 mR/hr were observed. Two random grab samples had traces of gold and silver, and less than 0.001 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Prospect

Index Map No.: Plate 5, No. 4

Location: Sec. 28, T. 46 N., R. 23 E.

Elevation: 2088 m

Access: By State Highway 34A, 8 km west from junction with State Highway 8A, then cross-country travel 3 km south

Geology of deposit: Gray rhyolite with iron-oxide surface coatings

Development: Claim monument

Sampling: The area was checked for radioactivity with a scintillation counter. No readings exceeding a background of 0.02 to 0.03 mR/hr were observed. One random grab sample had no anomalous metallic content.

Conclusions: No economic mineral potential.

Name: Prospect

Index Map No.: Plate 5, No. 8

Location: Sec. 3, T. 44 N., R. 23 E.

Elevation: 1920 m

Access: By State Highway 8A, 24 km south from junction with State Highway 140, then by cross-country travel 1.6 km west

Geology of deposit: Basalt capping volcanic sediments

Development: 4.6-m-diameter pit

Sampling: The area was checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.025 to 0.03 mR/hr were observed. Two chip samples of basalt contained traces of gold and silver and less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Rainbow Ridge Opal mine

Owner: Keith Hodson

Index Map No.: Plate 5, No. 25

Location: Secs. 22 and 23, T. 45 N., R. 26 E.

Elevation: 1524 m

Access: By dirt road 8 km south from Duffurrena Sub-headquarters

History: The first discovery of precious opal in Virgin Valley reportedly took place in 1905 or 1906 where the Rainbow Ridge Opal mine is presently located (Hodson and Dake, 1950). The original claims were owned by D. Roop, E. McGee, and George T. Hill (U.S. Geol. Survey, 1913).

Opal chips were found on the east side a of small hill in 1908, and a tunnel, about 100 m long, was dug (Hodson and Dake, 1950). A large open cut is at the site of the original portal.

In 1917, the Roebling Opal, weighing 2,665 carats (553 g), was found at the Rainbow Ridge mine. It was purchased by the late Colonel Roebling and is on display in the U.S. National Museum in Washington, D.C. At time of discovery, the opal was valued between $50,000 and $250,000 (U.S. Geol. Survey and Nevada Bur. Mines, 1964).

In 1929, six claims were patented; the Royal Opal, Rincon Belle, Black Opal Nos. 1, 2, and 3, and Pandora.

Little work was done at the Rainbow Ridge Opal Mine from 1920 until 1949 when Keith Hodson purchased the claims, installed electric lights in the underground mine, and started several crosscuts and a drift. He also excavated two large open cuts. In 1952, while working underground, he discovered the Hodson black fire opal weighing 2.95 kg, then valued at $50,000 (U.S. Geol. Survey and Nevada Bur. Mines, 1964).

During the past several years, Mr. Hodson has been working the Virgin Opal claim, which he purchased in 1955, and consequently, little work has been performed at the Rainbow Ridge Opal mine.

Previous production: Two very large, and numerous smaller, precious opals.

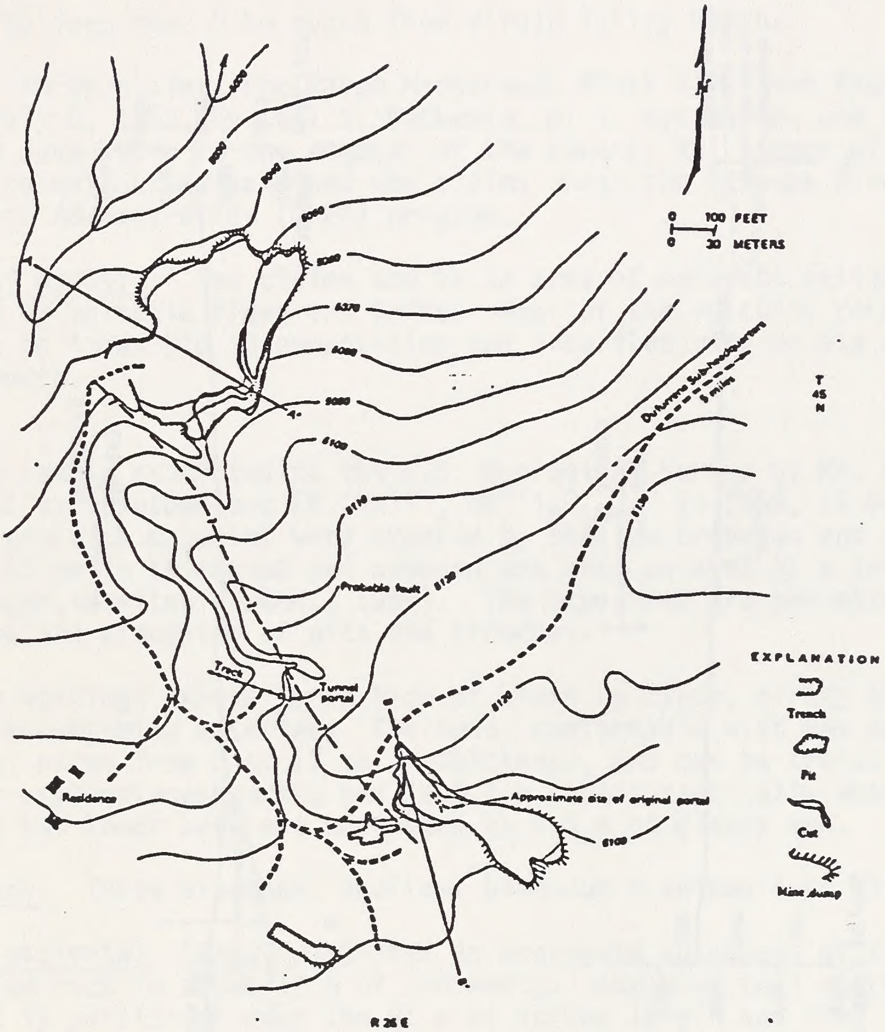
Geology of deposit: The Rainbow Ridge Opal mine is underlain by nearly horizontal ash, tuff, and tuffaceous sandstone beds. The opal-bearing horizon averages 1.2 m thick and is predominantly bentonite containing pods of ash, rhyolite pebbles, petrified wood, and opal. The amount of petrified wood increases downward within the opal-bearing horizon, Precious opal at the Rainbow Ridge Opal mine occurs as "conk" and as void fillings left where wood has rooted away. "Conk" is formed when opal fills the voids between growth rings in partially petrified wood.

Development: Two large cuts and eight smaller pits were observed (fig. 31). The largest cut is 97.5 m long, 76.2 m wide, and exposes a 10.4-m vertical section; the smaller is 45.7 m long, 70.1 m wide, and exposes a 6.7-m vertical section. Undergound workings total an estimated 228 m. The Hodsons have a home, trailer house, work shop, and rock display room on the property.

Sampling: Sampling consisted of digging into exposed beds and observing the presence or absence of indicators of precious opal. Fragments of precious opal were observed at numerous places.

Conclusions: The precious opal potential is high. More than 8.1 h are underlain by the precious opal-bearing horizon and projections of the strike and dip suggest substantially more.

The opalescence of the black fire opals found at Rainbow Ridge Opal mine is equal to the best in the world; however, the quality of the opal for cut gems is poor. Cabochons cut from the opal usually check within five years (Hodson and Dake, 1950).



N
0 100 FEET
0 30 METERS
T
45
N
R 26 E
A
A'
6100
6110
6120
6130
6100
Dufurrena Sub-headquarters
9 miles
Probable fault
Track
Tunnel portal
Residence
Approximate site of original portal
EXPLANATION
Trench
Pit
Cut
Mine dump

Figure 31.--Rainbow Ridge Opal mine.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

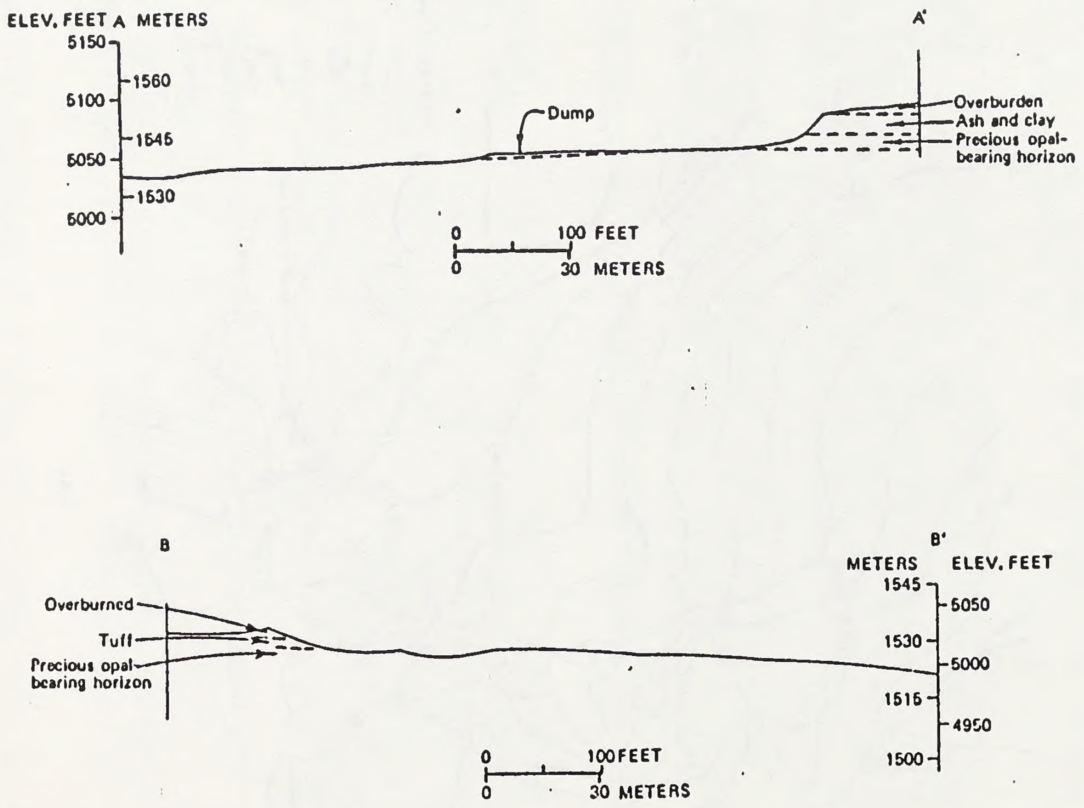

ELEV. FEET
A
METERS
5150
5100
5050
5000
1560
1545
1530
Dump
A'
Overburden
Ash and clay
Precious opal-bearing horizon
0
100 FEET
0
30 METERS
B
Overburned
Tuff
Precious opal bearing horizon
B'
METERS
ELEV. FEET
1545
1530
1515
1500
5050
5000
4950
0
100FEET
0
30 METERS

Figure 31a.--Rainbow Ridge Opal mine.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Name: Raven Manganese group

Index Map No.: Plate 5, No. 34

Location: Sec. 15, T. 44 N., R. 25 E.

Elevation: 1743 to 1768 m

Access: By jeep road 6 km south from Virgin Valley Ranch.

History: Three claims, the Raven Manganese, Black Bird, and Eagle, were located July 8, 1953, by Carl S. DuChemin, D. S. Symington, and A. G. Knab. In June 1959, at the request of the owners, Hal Stager of the U.S. Geological Survey examined the claims under the Defense Minerals Exploration Adminstration (DMEA) program.

Geology of deposit: The claims are in an area of moderate relief underlain by volcanic flows and tuffs. Most of the volcanic rocks are rhyolitic to andesitic in composition and area flatlying or dip a few degrees north.

One sample submitted to the U.S. Geological Survey by Mr. Knab was identified as cryptomelane $[K\ (Mn^{2+}, Mn^{4+})_8 O_{16}]$. In 1959, 17 beds of cryptomelane-rich material were exposed by shallow trenches and pits. They averaged 15 cm in thickness and cropped out over an area 91 m long and 30 m wide (Stager, written commun., 1959). The exposures are now obscured by the weathering and sloughing of pits and trenches.

The workings expose three beds of brown to black, earthy to slaty, cryptomelane-bearing material. The beds, conformable with the bedding of the volcanics, range from 8 to 13 cm in thickness, and can be traced for 24 m. The upper crytomelane-bearing bed is 3.7 m stratigraphically above the other two. The two lower beds are separated by 0.3 m of glassy ash.

Development: Three sloughed, shallow, hand-dug trenches 4 to 23 m long

Resource estimate: Stager estimated an aggregate thickness of 2.4 m of mineralized rock in about 15 m of sediments. Assuming this aggregate thickness is persistent over the 91 m of strike length and that it extends downdip 31 m, there are about 18,000 t of mineralized rock containing as much as 10 percent manganese in about 113,000 t of material.

Conclusions: Because the mineralized rock is in thin beds throughout nonmineralized material, considerable dilution would occur during mining. This, together with the small tonnage and low grade, makes the resource submarginal at best.

Name: Royal Peacock mine

Owner: Harry W. Wilson

Index Map No.: Plate 5, No. 27

Location: Secs. 17, 18, 19, and 30, T. 45 N., R. 26 E.

Elevation: 1494 to 1676 m

Access: By Virgin Valley road 13 km south from junction with State Highway 140

History: The date of the original location and the name of the locator are unknown. During the 1920's and 1930's, Mr. Rhinehart and Dan Arachevaleta owned a group of claims where the present group is located: Kelly, Skajwm, Royal Peacock Nos. 1 and 2, Northern Light, Peacock Nos. 2-4, Phantom, Little Pebble, Pebble, Angel Nos. 1 and 2, Starfire, Red Ball, Yellow Ball, Star Bright, and Blue Ball. Flora Haines Locheed and Mark Foster relocated the claims in 1937. In 1939, Flora Locheed quit claimed her interest to Mark Foster. H. W. Wilson's father purchased the group in 1942. In 1968, the claim group was leased by William J. Kelley. Mr. Kelley formed Opals Incorporated, and with the help of Allan Carlson, discovered a method of stabilizing Virgin Valley opal. Opals Incorporated last worked the claims in 1973. Harry W. Wilson bought the company in July 1974, and produced a small amount of opal during the remainder of the year. In 1975, Wilson stripped overburden in preparation for production in 1976.

Previous production: There is no record of production prior to 1969, but a small amount of opal was mined and sold locally according to H. W. Wilson.

Opals Incorporated produced 363 kg of opal in 1970, and 354 kg in 1971. Although the total 1972 yield is unknown, it included one rich pocket which sold for more than $90,000 (wholesale price). In 1973, 227 kg were reported. The Royal Peacock opal, weighing 191 carats (38.2 g) was found in 1970, and may be worth $250,000. The higher-quality opals were purchased by Beverly Hills Gems. Production through 1972 was from the Royal Peacock Nos. 1 and 2, and thereafter from the Northern Light. Approximately one percent of the mined opal was classified as precious opal, and it brought from $250 to $500 per carat wholesale. In 1974 Wilson's total production was 18 kg, of which slightly more than 2.7 kg were precious opal. There was little production during 1975, but it is scheduled to be resumed in 1976.

Geology of deposit: The claims are underlain by ash, tuff, and tuffaceous sandstone beds, which strike northwest and dip 2' to 4' NE. The opal-bearing horizon is as much as 2 m thick and is predominantly greenish bentonite containing pods of ash, rhyolite pebbles, petrified wood, and opal. At the Pebble claim, only slight amounts of petrified wood are associated with the opal. Wilson said the water content of mined opal was found to increase westwardly from the Royal Peacock No. 1 to the Northern Light.

Development: Seven large cuts and many smaller pits and trenches were observed (figs. 32 and 33). According to Wilson, when Opals Incorporated began production, seven adits were on the property. They apparently date back to the late teens and early 1920's. The largest cut on the Royal Peacock Nos. 1 and 2 claims is 283 m long, 24 m wide, and exposes a 8.8 m vertical section.

Sampling: Sampling consisted of digging into exposed beds and observing the presence or absence of precious opal indicators. Fragments of precious opal were observed at numerous places.

Conclusions: About 22 h underlain by the opal-bearing horizon are minable. This is based on a strike length of 3,660 m and an economic width limit of 61 m. Beyond 61 m, the stripping ratio would be excessive. The likelihood of additional precious opal is high.

Name: Skyline group

Index Map No.: Plate 5, No. 7

Location: Secs. 17, 21, 28, and 33, T. 46 N., R. 24 E.

Elevation: 1768 m

Access: By State Highway 8A, 3 km southeast from junction with State Highway 140

History: The group consists of nine claims, the Skyline, Nine, Sally, Grace, Dorothy, and Maud J. Nos. 1-4, which were located in 1941 by Mr. Mustard for manganese.

Geology of deposit: The claims are underlain by recent alluvium and rhyolite that contains vugs, some of which are filled by agate.

Development: One pit

Sampling: Six samples from rock in place and from the dump of the pit showed as much as a trace gold and silver and 0.4 percent manganese.

Conclusions: No economic mineral potential.

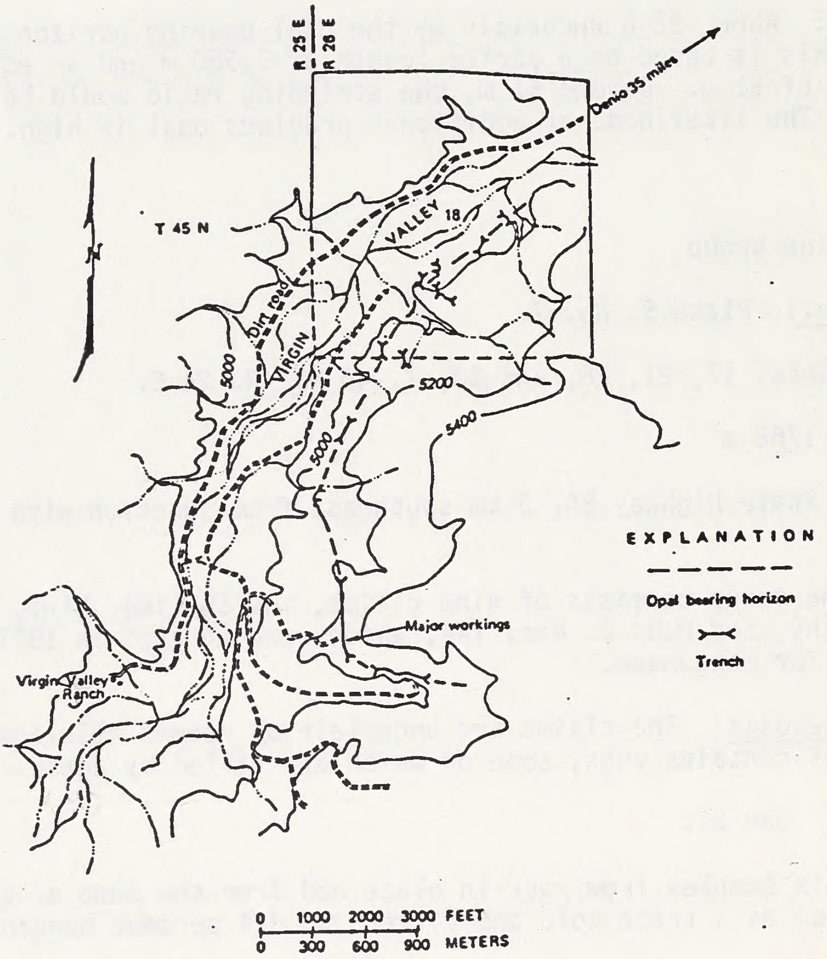

R 25 E
R 26 E
Denio 35 miles
T 45 N
N
VALLEY
18
VIRGIN
Dirt road
5000
5200
5400
5000
Major workings
Virgin Valley Ranch
EXPLANATION
Opal bearing horizon
Trench
0 1000 2000 3000 FEET
0 300 600 900 METERS

Figure 32.--Royal Peacock mine.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

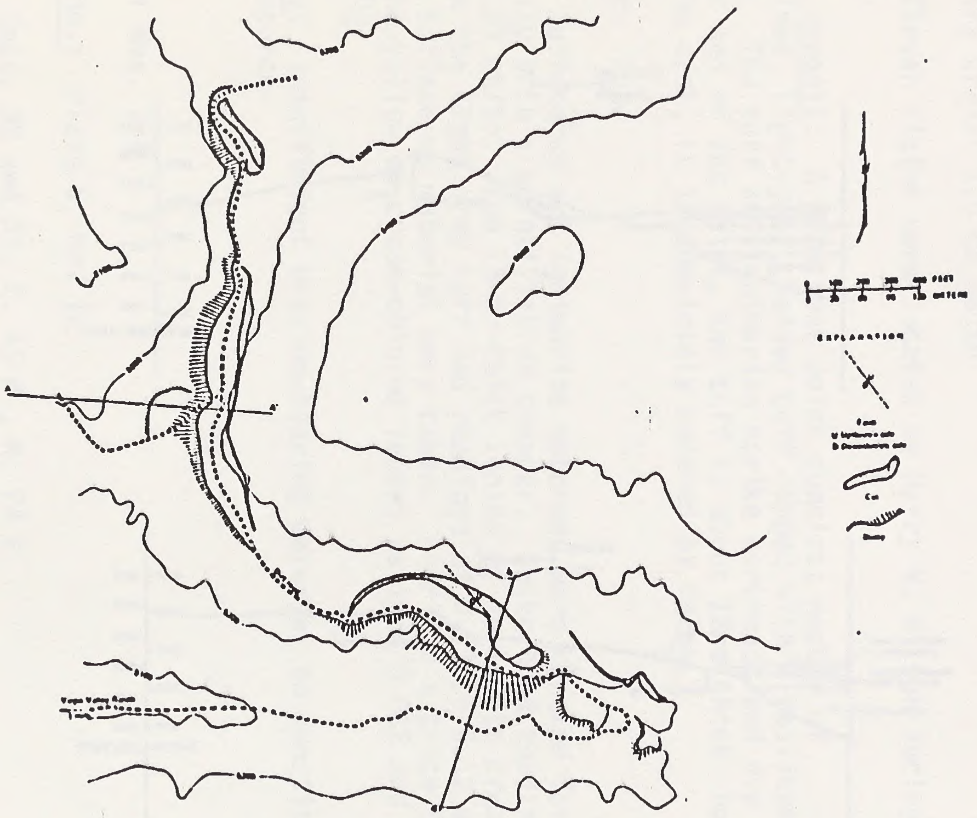

FEET
METERS
EXPLANATION
Fault
U Upthrown side
D Downthrown side
Cut
Dump

Figure 33.--Major workings, Royal Peacock mine.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

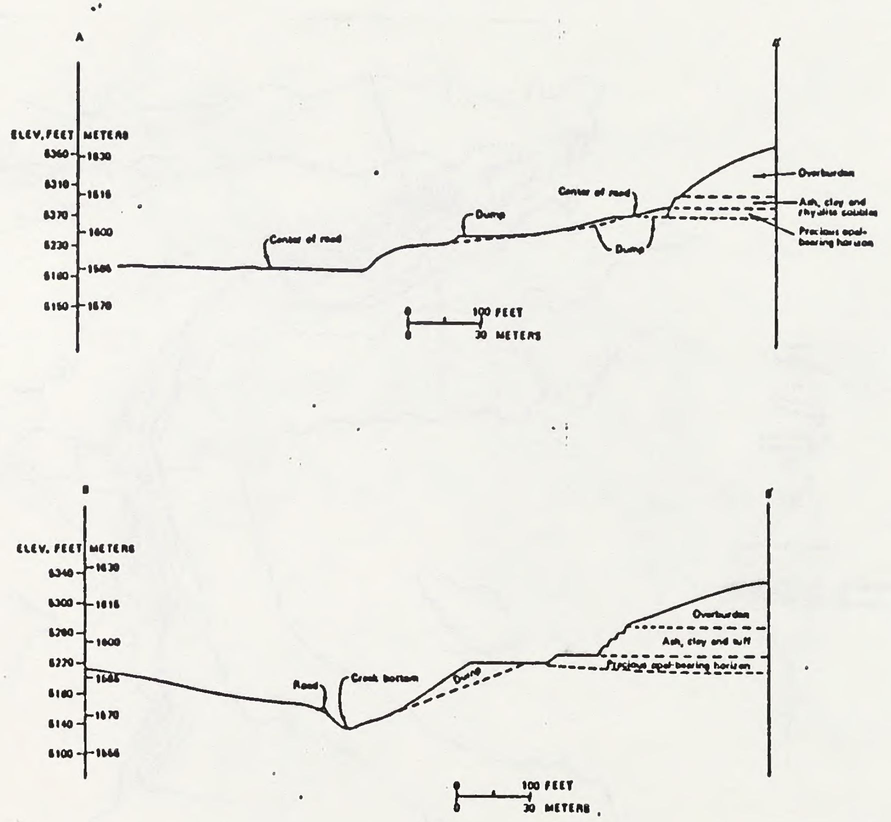

A
A'
ELEV, FEET
METERS
5360
5310
5270
5230
5180
5150
1630
1615
1600
1585
1570
Center of road
Dump
Center of road
Dump
Overburden
Ash, clay and rhyolite cobbles
Precious opal-bearing horizon
0
100 FEET
0
30 METERS
B
B'
ELEV. FEET
METERS
5340
5300
5260
5220
5180
5140
5100
1630
1615
1600
1585
1570
1555
Road
Creek bottom
Dump
Overburden
Ash, clay and tuff
Precious opal-bearing horizon
0
100 FEET
0
30 METERS

Figure 33a.--Major workings, Royal Peacock mine.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Name: Steamboat group

Index Map No.: Plate 5, No. 32

Location: Secs. 3 and 10, T. 44 N., R. 25 E.

Elevation: 1646 m

Access: By dirt road 0.8 km from Virgin Valley Ranch, then by cross-country travel 1.6 km south

History: Eleven claims were located by Harry W. Wilson during May and June, 1955.

Geology of deposit: A prominent point consists mostly of coarse-grained, light-gray, bedded tuff capped with a resistant ignimbrite. The tuff and ignimbrite strike northeast and dip 15' SE. At the west end of the point, the tuff is about 18 m thick; however, 244 m to the east, it is completely covered by talus.

Development: None

Sampling: Tuffaceous and ignimbrite outcrops were checked for radioactivity with a scintillation counter. Background readings were 0.025 to 0.03 mR/hr. Two 15-cm-thick lenses of yellow to cream-colored tuff within the light gray tuff had readings of 0.11 to 0.12 mR/hr. Six samples of tuffaceous material were taken. Four had a trace U_3O_8 and two from the yellow to cream-colored lenses assayed 0.032 and 0.037 percent U_3O_8.

Conclusions: Insufficient uranium-bearing material to constitute a mineral resource.

Name: Suni Nos. 1-3

Index Map No.: Plate 6, No. 12

Location: Secs. 32 and 33, T. 45 N., R. 24 E.

Elevation: 1881 to 1887 m

Access: By State Highway 8A, 19 km south from junction with State Highway 140, then by dirt road 5 km east

History: Located in 1955 by Kenneth Arnold

Geology of deposit: Residual soil and colluvium over rhyolite bedrock

Development: Five shallow bulldozer cuts

Sampling: Bulldozer cuts were checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.015 to 0.03 mR/hr were observed. Three samples of soil with rhyolite and obsidian float were taken from bulldozer cuts. All had values of less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Sunny Jim

Index Map No.: Plate 5, No. 10

Location: Sec. 32, T. 45 N., R. 24 E.

Elevation: 1905 m

Access: By State Highway 8A, 19 km south from junction with State Highway 140, then by dirt road 3.2 km east

History: Located in 1955 by Bob Wees

Geology of deposit: Colluvium and alluvium over rhyolite bedrock

Development: Shallow bulldozer cuts

Sampling: Bulldozer cuts were checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.02 to 0.04 mR/hr were observed. A sample of soil and rhyolite float from a bulldozer cut had less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Viola and Nellie group

Index Map No.: Plate 5, No. 40

Location: Sec. 7, T. 43 N., R. 24 E.

Elevation: 2019 m

Access: By State Highway 8A, 27 km south from junction with State Highway 140, then by dirt road 11 km south

History: The Viola Nos. 1-3 and Nellie Nos. 1-3 claims were located in 1955 by Leo Roessler.

Geology of deposit: Weathered rhyolite

Development: None

Sampling: The area was checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.02 to 0.03 mR/hr were observed. Five random chip samples of rhyolite each contained less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Virgin Duff group, Pronghorn group, and Beverly No. 1

Index Map No.: Plate 5, No. 16

Location: Secs. 30 and 31, T. 46 N., R. 26 E., and Secs. 25 and 36, T. 46 N., R. 25 E.

Elevation: 1524 m

Access: By State Highway 140, 51 km west from Denio

History: The groups consist of 17 claims, located in 1955 and 1956 by Paul Viles, Cliff Poulsen, Harold Gleason, and Dan Thompson.

Geology of deposit: The area is underlain by recent alluvium and gray to dark-purplish rhyolite. No mineralized structures were observed.

Development: Sixteen bulldozer cuts in alluvium

Sampling: All bulldozer cuts and outcrops were checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.025 to 0.035 mR/hr were observed. Nine samples from rock in place and from bulldozer cuts assayed no more than a trace silver and less than 0.005 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Virgin Opal (Bonanza) mine

Owner: Keith Hodson

Index Map No.: Plate 5, No. 21

Location: Secs. 6 and 7, T. 45 N., R. 26 E.

Elevation: 1585 to 1707 m

Access: By Virgin Valley road 8 km southwest from Duffurrena Sub-headquarters, then by dirt road 3 km northwest

History: The early history of the claim, locally referred to as the Bonanza, is vague. The original location was probably in 1908 by Ivan Dow, George Mathewson, Alfred Thompson, and others. In 1943, it was relocated as the Virgin Opal claim by Mr. Garaventa. Keith Hodson, the present owner, purchased it in 1955 (U.S. Geol. Survey and Nevada Bur. Mines, 1964).

Previous production: One broken precious opal weighing a total of 3.3 kg was discovered by Mr. Hodson. Many smaller precious opals have been recovered.

Geology of deposit: The claim is underlain by nearly horizontal ash, tuff, and tuffaceous sandstone beds. The opal-bearing horizon averages more than 1.2 m thick and consists primarily of light-colored bentonite containing varying amounts of petrified wood, rhyolite pebbles, ash, and opal. Precious opals are usually found in the upper half of the horizon.

Development: Two large cuts, one small cut, one adit, and one storage building were observed (figs. 34, 35, and 36). The larger cut is 123 m long, 15 m wide, and exposes a 16-m vertical section. The other large cut is 88 m long, 30 m wide, and exposes a 21-m verticle section

Sampling: Sampling consisted of digging into exposed beds and observing the presence or absence of precious opal indicators. Fragments of precious opal were observed at numerous places.

Conclusions: About 1.6 h underlain by the opal-bearing horizon are minable. This is based on a strike length of 550 m and an economic width limit of 30 m. Beyond 30 m, the stripping ratio would be excessive. The potential of additional precious opal is high.

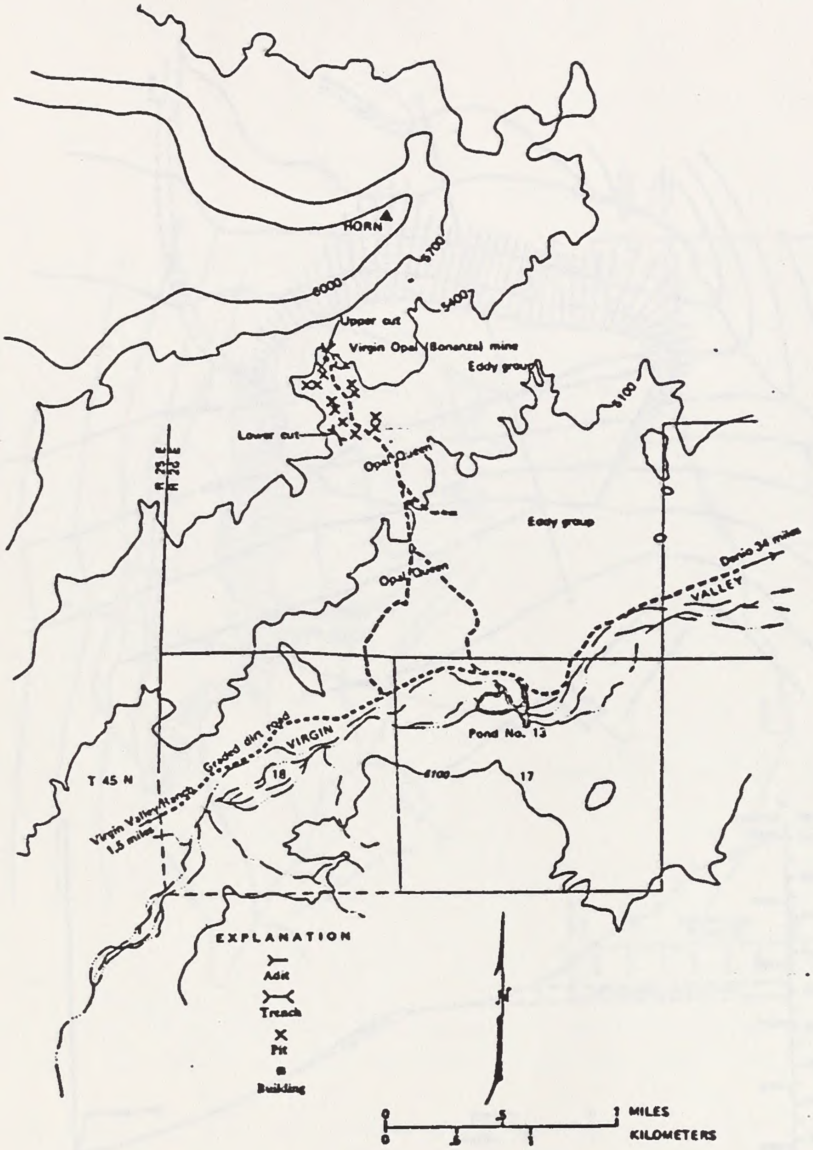

HORN
6000
5700
5400
6100
Upper cut
Virgin Opal (Bonanza) mine
Eddy group
Lower cut
Opal Queen
Opal Queen
Eddy group
R 25 E
R 26 E
Denio 34 miles
VALLEY
Pond No. 13
Graded dirt road
VIRGIN
18
17
6100
T 45 N
Virgin Valley Ranch 1.5 miles
EXPLANATION
Adit
Trench
Pit
Building
N
0 .5 1 MILES
0 .5 1 KILOMETERS

Figure 34.--Workings, Virgin Opal (Bonanza) mine.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

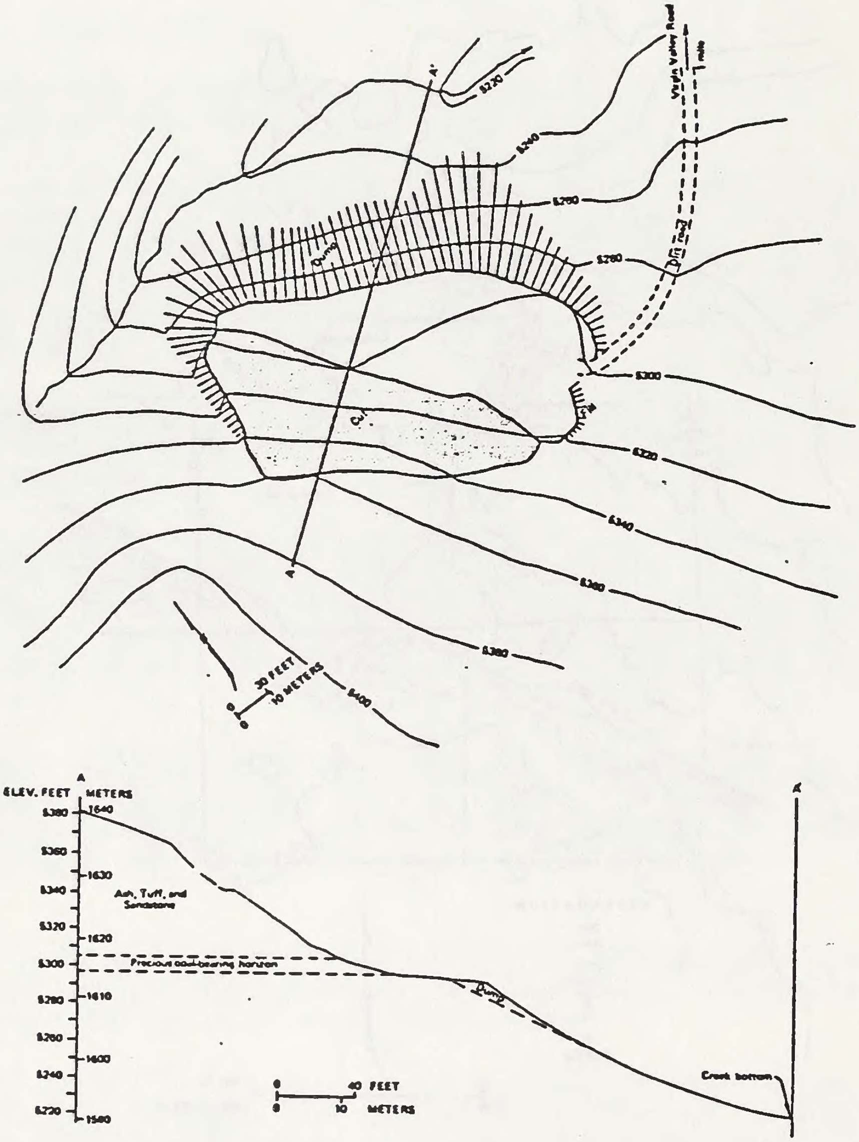
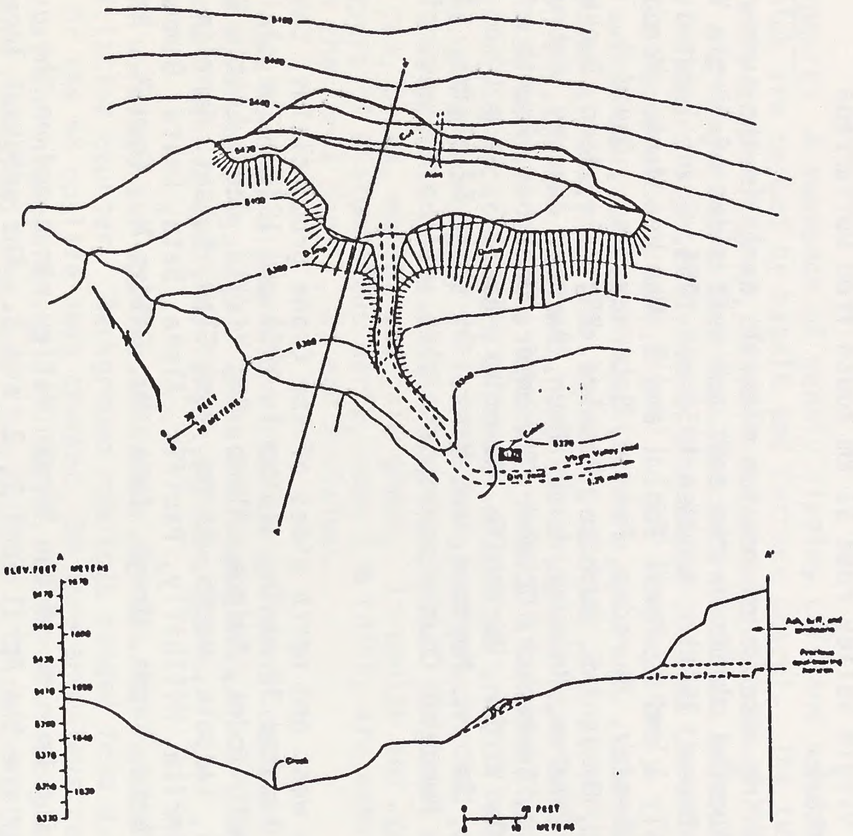

Virgin Valley Road
1 mile
A'
6220
6240
6260
6280
Dump
Dirt road
6300
Cut
Fill
6320
6340
6360
6380
6400
A
0
30 FEET
0
10 METERS
A
ELEV. FEET
METERS
6380
1640
6360
1630
6340
Ash, Tuff, and Sandstone
6320
1620
6300
Precious opal-bearing horizon
6280
1610
Dump
6260
1600
6240
6220
1590
0
40 FEET
0
10
METERS
Creek bottom
A'

Figure 35.--Lower cut, Virgin Opal (Bonanza) mine.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.



A
A'
ELEV. FEET
METERS
Creek
FEET
METERS
Adit
Dump
Cabin
Virgin Valley road
Dirt road

Figure 36.--Upper Cut, Virgin Opal (Bonanza) mine.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Name: Virgin Valley uranium claims

Owners: G. Kreiger, Mitchel, V. Ruedy, J. Crane, and H. Wilson.

Index Map No.: Plate 5, No. 28

Location: Secs. 2, 3, T. 44 N., R. 25 E., Secs. 12, 13, 24, 25, and 36, T. 45 N., R. 25 E., Secs. 30, 31, T. 45 N., R. 26 E.

Elevation: 1524 to 1890 m

Access: By Virgin Valley road 11 km south from Duffurrena Sub-headquarters

History: Having discovered uranium minerals early in the summer 1950, Jack Crane located claims on the east and west sides of Virgin Valley (Staatz and Bauer, 1951). Between 1950 and 1954, Crane located the Fourth of July 1 and 2, April Fool 1 and 2, Wee Wee Marie, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Tony, David B., Afterthought, Dixie 1-5, Suprise, Rosalee, Big Hole, Reno, Buckhorn, Sweetwater, Cameron, Holiday, Lucky Four, Barney, January, February, March, August, September, October, November, December, Fourth of July, Fangle, Little Virgin, Jackknife, Maverick, Ace 1-3, Bing 1 and 2, Pluto, Venus, Saturn, Neptune, and Mars. Of these 52 claims, 13 are shown on the Humboldt County surveyor's plat, all on the west side of Virgin Valley.

On the west and north sides of the Crane group claims, the Lone Star Uranium Co. located 36 mining claims in 1954 and 1955. The claims are the Jackal, Kismet, Todos, Amigos, Alamo, Big Virgin, Jeep, Little Big Horn, Tatie, Jo Jo, Tadpole, Hepto, Bongo, Moon Glow, Sunset, Sunrise, Sunny Jim, Lucky Dog, Sprite, Hillbilly, Pacific, Alpha, Beta, Delta, Gamma, Epsilon, Zeta, Eta, Theta, Kappa, Omega, Iota, Mu, Galdys M., Faun P., Paiute, and Vadore.

About 0.8 km east of the Virgin Valley ranch and on the east side of Virgin Valley are the April Fool 1, 2, and 3. The original locator is unknown. Mark Foster relocated the claims in 1937. In 1942, The Wilson family bought them from Foster. Harry W. Wilson is now the sole owner.

Harry W. Wilson has relocated some of the claims north of Virgin Valley Ranch previously claimed by Jack Crane as the Angie 1, 2, and 3 in 1976. Harry W. Wilson and Gus Kreiger located 11 claims around the Angie group in 1976. The claims are the Barbara, Barbara 1-4, and Hal and Hal 1-7.

Gus Kreiger located a block of 132 claims southeast of Virgin Valley ranch in 1976. They were the Mule, Jackass, Donkey, Charlawne, Charlotte 1-22, Jane 1-13, East Rim 1-11, 13-23, 13-23, 25-35, 37-47, 49-59, South Rim 1-20, Mars, Neptune, Saturn, Venus, and Pluto.

During 1976, Kreiger, Mitchell, Ruedy, Crane, and Wilson made an agreement to promote all their claims as a unit to interested mining companies. To date, several companies have expressed an interest.

Previous production: Greenish-yellow, translucent, fluorescent opalite which occurs at the top of a diatomaceous earth bed on the April Fool group was sold for 77 cents/kg from 1937 to 1942 to rock collectors and the Ultraviolet Corp., in San Gabriel, California. After Wilson purchased the group, he also sold opalite to Raytech, Inc., in Massachusetts. Between 14 and 18 t have been sold since 1942.

Geology of deposit: A sequence of gently dipping tuff and ash beds at least 91 m thick are capped by basalt and terrace gravel. The tuff layers are mostly greenish-gray, friable and porous; traces of fibrous gypsum, iron- and manganese-oxides coat fracture surfaces. The ash beds are generally thinner, lighter colored, and finer grained than the tuff. The beds strike northwesterly and dip 5' to 10' northeasterly. Forty-five discontinuous layers of opalite were observed. Some had anomalous amounts of uranium. The layers of opalite occur parallel to the bedding of the ash and tuff and range in thickness from 0.03 to 1 m. The length of the exposed opalite layers is from 2 m to more than 366 m. Many stages of silicification were observed. Less silicified beds resemble shale while thoroughly silicified beds are massive and translucent. The opalite has a distinctive conchoidal fracture, and is gray, brown, tan, black, white, and pale green. Irregular and lense-like layers of diatomaceous earth, some 2 m thick, are exposed for over 610 m on the April Fool 1, 2, and 3 claims.

Development: One hundred eighty-eight shallow bulldozer cuts and trenches were observed (fig. 37). Three bulldozer cuts on a hillside below the airport have a combined length of over 610 m.

Sampling: All workings and opalite beds were checked for radioactivity with a scintillation counter. Background readings ranged from 0.015 to 0.05 mR/hr. Of the 48 opalite beds checked, 10 have anomalous readings in a few places, the highest being 0.90 mR/hr. Sixty-four samples of opalite and tuff contained from less than 0.02 to 0.08 percent U_3O_8. Seventeen samples had 0.02 percent or more U_3O_8 (Table 6). The highest sample results came from a hillside exposure near the airstrip. Table 6 also gives analytical results for gold and silver. Analyses of the diatomaceous earth indicated good brightness but no potential as a filter aid.

Resource estimate: An area north of Virgin Valley Ranch, which is approximately 1.6 by 0.4 km wide and 15 m deep, may contain 14 to 18 million t of low-grade, uranium-bearing material constituting a submarginal resource.

Conclusions: The uranium mineralization encountered indicates some potential for discovery of additional submarginal resource and possibly discovery of ore grade uranium deposit.

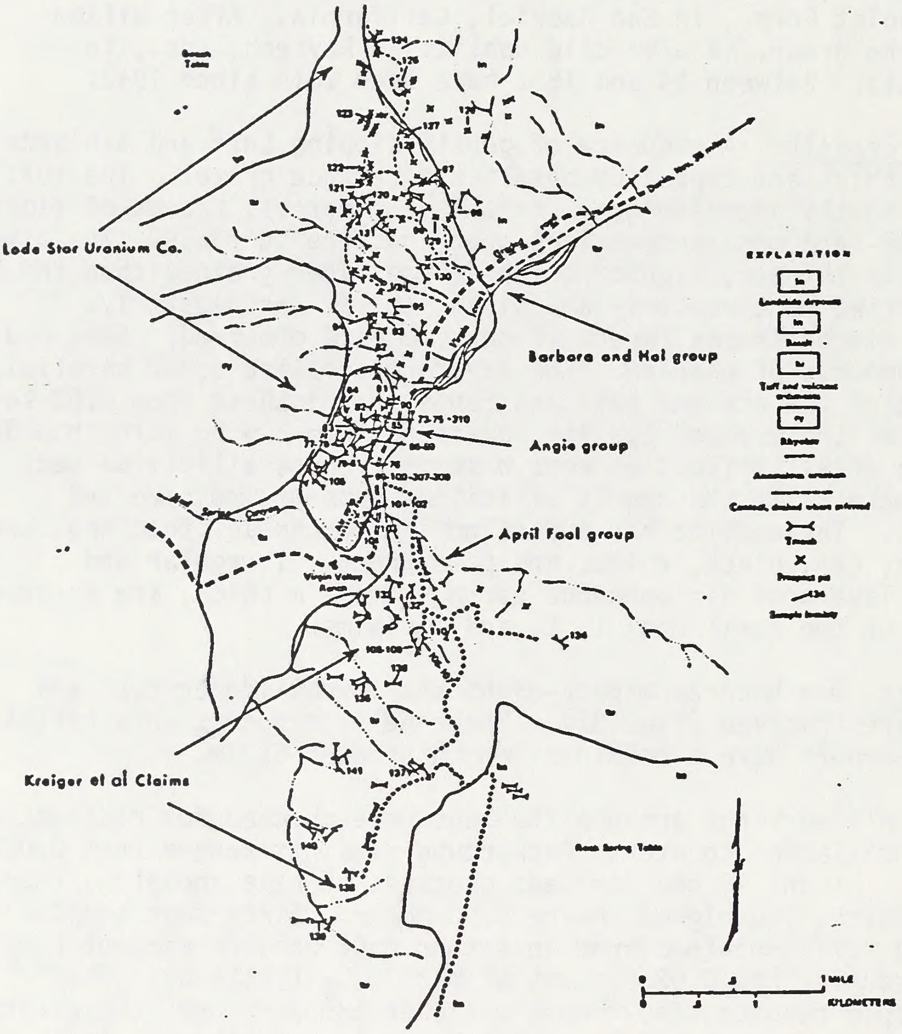

Lode Star Uranium Co.
Barbara and Hal group
Angie group
April Fool group
Kreiger et al Claims
Virgin Valley Ranch
EXPLANATION
Landslide deposits
Basalt
Tuff and volcanic sediments
Rhyolite
Anomalous uranium
Contact, dashed where inferred
Trench
Prospect pit
134
Sample locality
1 MILE
KILOMETERS

Figure 37.--Workings, Virgin Valley uranium claims.

Charles Sheldon wilderness study area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon.

Table 6.--Workings, Virgin Valley uranium claims (to accompany fig. 37)

Sample analyses for Virgin Valley uranium claims.

[Tr, trace; N, not detected; --, not analyzed; <, less than shown]

Sample				Gold (grams per metric ton)	Silver (grams per metric ton)	U_3O_8 (percent)
No.	Type	Length (meters)	Description			
73	Chip---	0.12	Brown to dark-gray opalized tuff	N	N	0.033
74	do-----	.18	do------------------------------	N	N	.009
75	do-----	.39	do------------------------------	N	N	.005
76	do-----	.21	do------------------------------	N	N	<.002
77	do-----	.36	Gray opalized tuff with wood fragments----------------------	N	N	<.002
78	do-----	.30	do------------------------------	N	N	.064
79	do-----	.12	Red to gray opalized tuff-------	N	N	.033
80	do-----	.30	do------------------------------	N	7	.027
81	do-----	.27	White and gray massive opalite--	N	7	.007
82	do-----	.27	Gray tuff with black carbonaceous fragments----------	N	N	.048
83	do-----	.69	do------------------------------	N	N	.021
84	do-----	0.27	Gray ruff with black carbonaceous fragments	Tr	N	0.020
85	do-----	.63	Tan to brown opalized tuffs-----	N	N	.036

Sample				Gold (grams per metric ton)	Silver (grams per metric ton)	U_3O_8 (percent)
No.	Type	Length (meters)	Description			
86	Chip--	.21	Olive-green opalite-------------	N	N	.004
87	do----	.39	do------------------------------	N	Tr	<.002
88	do----	.30	Brown opalized tuff-------------	N	Tr	.046
89	do----	.39	Brown to gray opalized tuff-----	N	N	<.002
90	do----	.33	Gray partially opalized tuff----	N	N	<.002
91	do----	.54	Green massive opalite and white to cream tuff------------------	Tr	N	.017
92	do----	.57	Brown to green opalite----------	Tr	3	.011
93	do----	.27	do------------------------------	N	N	.017
94	do----	.27	do------------------------------	N	N	.012
95	do----	1.20	Brown opalized tuff-------------	N	N	.013
96	do----	.21	Gray opalite--------------------	N	N	<.002
97	do----	.48	Brown, orange, and gray opalized tuff---------------------------	N	N	<.002
98	do----	0.60	Brown, orange, and gray opalized tuff---------------------------	N	N	<0.002
99	do----	.54	Gray opalized tuff and gray tuff	N	N	.030

Sample				Gold (grams per metric ton)	Silver (grams per metric ton)	U_3O_8 (percent)
No.	Type	Length (meters)	Description			
100	Chip--	.27	Gray opalized tuff-------------	N	N	.078
101	do----	.60	Brown to gray opalized tuff-----	N	N	.008
102	do----	.81	Gray opalized tuff and white tuff--------------------------	N	N	.030
103	do----	.99	Yellow to brown opalite and white tuff--------------------	Tr	N	.080
104	do----	.15	Yellow to brown opalized tuff---	N	N	.027
105	do----	.78	Yellow to brown-stained zone in white tuff--------------------	N	N	.036
106	do----	1.50	Diatomite---------------------	--	--	--
107	do----	.60	Cream to reddish translucent opalite-----------------------	N	N	.010
108	do----	.75	Diatomite---------------------	--	--	--
109	do----	.18	Cream, yellow and brown translucent opalite------------	N	N	.017
110	do----	0.30	Orange, brown, greenish opalized tuff-------------------------	N	N	0.007
120	do----	.66	Light-gray bedded tuff---------	N	N	.002
121	Grab--	--	Brownish tuff-----------------	N	N	<.002
122	do----	--	Light-gray tuff----------------	N	N	<.002
123	do----	--	do----------------------------	N	N	<.002
124	do----	--	White to gray tuff-------------	N	N	<.002
125	do----	--	do----------------------------	N	N	<.002
126	do----	--	do----------------------------	N	N	<.002
127	Random chip--	--	Light-gray tuff----------------	N	N	<.002
128	Grab--	--	White to gray tuff-------------	N	N	<.002
129	do----	--	do----------------------------	N	N	<.002

Sample				Gold (grams per metric ton)	Silver (grams per metric ton)	U_3O_8 (percent)
No.	Type	Length (meters)	Description			
130	Grab--	--	White to gray tuff--------------	N	N	<.002
131	do----	--	do------------------------------	N	N	<.002
132	do----	--	Orange to brown opalized tuff---	N	N	<.002
133	Chip--	0.69	Gray tuffaceous silstone--------	Tr	N	<0.002
134	Grab--	--	Gray tuff---------------------	N	N	<.002
135	Chip--	1.20	Thinly bedded white ash---------	N	N	<.002
136	Random chip--	--	Light-brown tuff----------------	N	N	<.002
137	Grab--	--	Dark-gray basalt----------------	N	N	<.002
138	do----	--	Light-brown tuff and dark-gray basalt------------------------	N	N	<.002
139	do----	--	do------------------------------	N	N	<.002
140	do----	--	do------------------------------	Tr	N	<.002
141	do----	--	Brown and gray tuff-------------	Tr	N	.002
307	Chip--	.45	Yellow to light-brown opalite---	--	--	.035
308	Random chip--	--	Yellow to brown opalized stump--	--	--	.053
309	Chip--	1.20	Gray opalized tuff--------------	--	--	.002
310	do----	.30	White tuff----------------------	--	--	.007

Name: Wild Rose

Index Map No.: Plate 5, No. 3

Location: Sec. 1, T. 45 N., R. 22 E., 2 miles (3.2 km) east of Swan Lake

Elevation: 1798 m

Access: By State Highway 34 A 10 km west from junction with State Highway 8A, then by cross-country travel 1.6 km north

History: Located August 7, 1927 by D. D. McLeod

Geology of deposit: Slightly vesicular basalt

Development: None

Sampling: One grab sample assayed a trace gold and less than 0.001 percent U_3O_8.

Conclusions: No economic mineral potential.

Name: Yellow Rock group

Index Map No.: Plate 5, No. 37

Location: Sec. 21, T. 44 N., R. 37

Elevation: 1887 to 1897 m

Access: By State Highway 8A 27 km south from junction with State Highway 140, then by dirt road 13 km east

History: Ten claims were located in 1955 by Yellow Rock Uranium Co.

Geology of deposit: Rhyolite and whitish volcanic tuff containing cinders

Development: Shallow bulldozer cuts

Sampling: All bulldozer cuts were checked for radioactivity with a scintillation counter. No readings exceeding a background count of 0.02 to 0.025 mR/hr were observed. Six random soil grab samples from bulldozer cuts and two random chip samples of rhyolite assayed a trace gold and silver and less than 0.001 percent U_3O_8.

Conclusions: No economic mineral potential.

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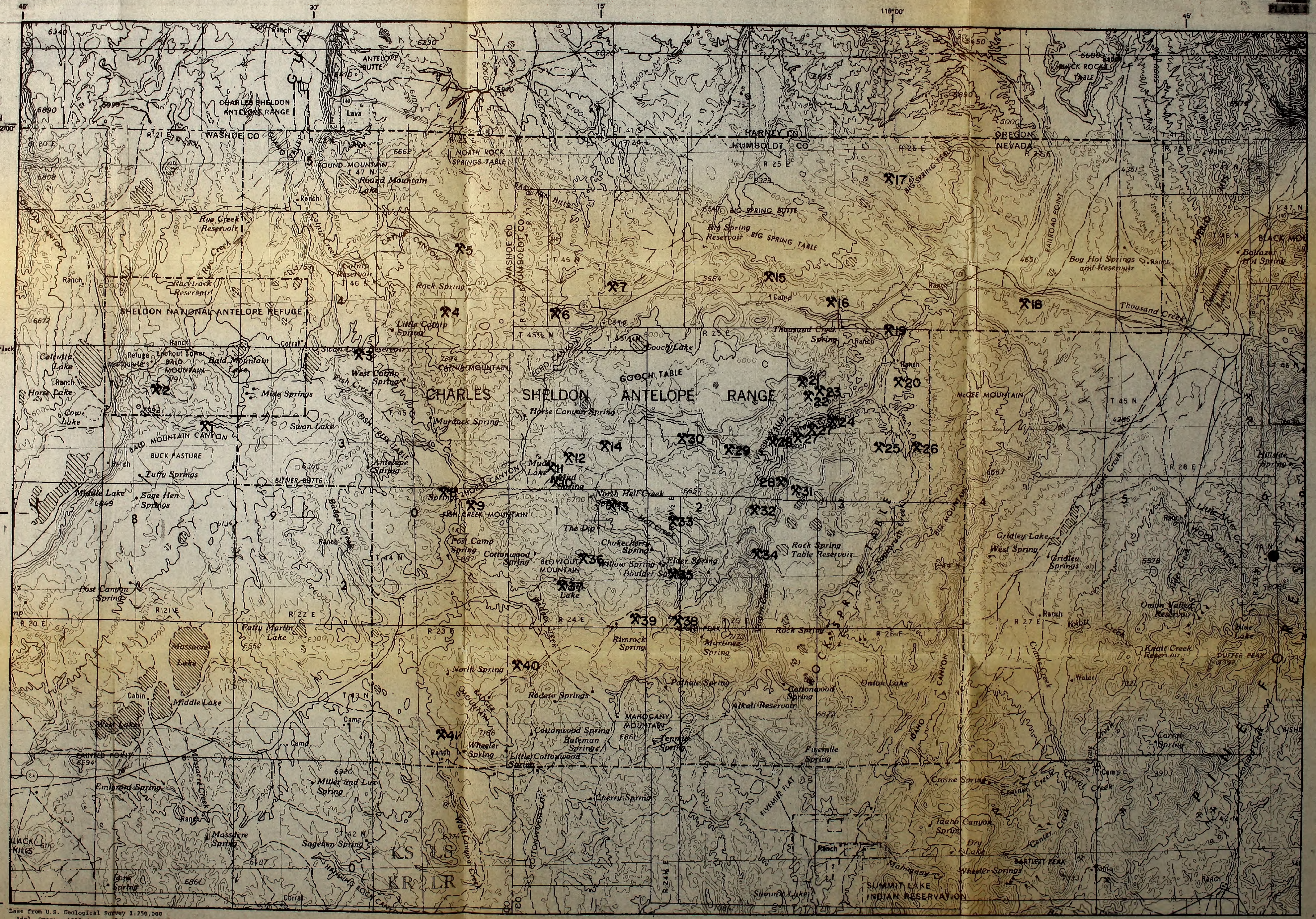
PLATE 5

EXPLANATION

⚒ Mine or prospect

MINES AND PROSPECTS

1 Antelope Nos. 1-18 (Lode Star Nos. 1-60)
2 Bald Mountain claims
3 Wild Rose
4 Prospect
5 Charline Nos. 1 and 2
6 Echo group
7 Skyline group
8 Prospect
9 Obsidian group, Columbia and Loise
10 Sunny Jim
11 Lucky Jim Nos. 1-8 and Apex
12 Suni Nos. 1-3
13 Bighorn group
14 Kim Nos. 1-9
15 McKenney Camp uranium claims
16 Virgin Ouff group, Pronghorn group, and Beverly No. 1
17 Lucky Four
18 Fortune group, Uranium King, and Lucky Jack
19 Lemac Nos. 1-5 Quarry
20 Goodwill
21 Virgin Opal (Bonanza) mine
22 Opal Queen group mine
23 Eddy group
24 Meyer group mine
25 Rainbow Ridge Opal mine
26 Lad and Shepardson's group
27 Royal Peacock mine
28 Virgin Valley uranium claims
29 Grubstake Nos. 1-4
30 Hope group
31 Mesa
32 Steamboat group
33 Lucky Strike
34 Raven Manganese group
35 Blue Dragon Nos. 1-3
36 Crater group
37 Yellow Rock group
38 Lucky Horseshoe group
39 Golden Cash, Jackpot, Buried Treasure, and Golden Horde
40 Viola and Nellie group
41 Pretty Rock group


45'
30'
15'
118°00'
45'
42°00'
45'
30'
CHARLES SHELDON ANTELOPE RANGE
ANTELOPE BUTTE
WASHOE CO
HUMBOLDT CO
HARNEY CO
OREGON
NEVADA
BLACK ROCK TABLE
NORTH ROCK SPRINGS TABLE
ROUND MOUNTAIN
Round Mountain Lake
BIG SPRING BUTTE
Big Spring Reservoir
BIG SPRING TABLE
Bog Hot Springs and Reservoir
Thousand Creek
Rue Creek Reservoir
Racetrack Reservoir
SHELDON NATIONAL ANTELOPE REFUGE
Catnip Reservoir
Rock Spring
Little Catnip Spring
CATNIP MOUNTAIN
GOOCH TABLE
Gooch Lake
Thousand Creek Spring
McGEE MOUNTAIN
Calcutta Lake
Horse Lake
Cow Lake
Refuge Headquarters
BALD MOUNTAIN
Bald Mountain Lake
Mule Springs
Swan Lake
West Catnip Spring
Murdock Spring
Horse Canyon Spring
BALD MOUNTAIN CANYON
BUCK PASTURE
Tuffy Springs
Antelope Spring
BITNER BUTTE
Middle Lake
Sage Hen Springs
FISH CREEK MOUNTAIN
North Hell Creek
The Dip
Chokecherry Spring
Elder Spring
Willow Spring
Boulder Spring
BLOWOUT MOUNTAIN
Post Camp Spring
Cottonwood Spring
Rock Spring Table Reservoir
Gridley Lake
West Spring
Gridley Springs
Onion Valley Reservoir
Blue Lake
Knott Creek Reservoir
DUFFER PEAK
Hillside Spring
Post Canyon Spring
Fatty Martin Lake
Massacre Lake
Middle Lake
West Lake
Rimrock Spring
Martinez Spring
North Spring
Rodero Springs
Pothole Spring
Alkali Reservoir
Cottonwood Spring
Onion Lake
MAHOGANY MOUNTAIN
Cottonwood Spring
Bateman Springs
Wheeler Spring
Little Cottonwood Spring
Fivemile Spring
Emigrant Spring
Miller and Lux Spring
Cherry Spring
Crane Spring
Corral Spring
Massacre Spring
Sagehen Spring
Idaho Canyon Spring
Dry Lake
BARTLETT PEAK
Wheeler Springs
SUMMIT LAKE INDIAN RESERVATION
Summit Lake
HANGING ROCK CANYON
Lone Spring
KS LS
KR LR
R 20 E
R 21 E
R 22 E
R 23 E
R 24 E
R 25 E
R 26 E
R 27 E
R 28 E
T 47 N
T 46 N
T 45 N
T 45½ N
T 44 N
T 43 N
T 42 N
T 41 S
Ranch
Camp
Corral
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
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41

Base from U.S. Geological Survey 1:250,000
Adel, Oregon, 1955 (rev. 1970); Vya, Nevada, Oregon, California, 1954 (rev. 1970).
Compiled Menlo Park Base Map Section (10-74)
(14-40)

SCALE 1:125 000
2 0 2 4 6 8 MILES
2 0 2 4 6 8 KILOMETERS

Field checked by Ernest T. Tuchek, F. J. Johnson, and M. D. Conyac, 1975

U.S. Geological Survey
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PLATE 5--MINES AND PROSPECTS IN THE CHARLES SHELDON WILDERNESS STUDY AREA, HUMBOLDT AND WASHOE COUNTIES, NEVADA, AND LAKE AND HARNEY COUNTIES, OREGON

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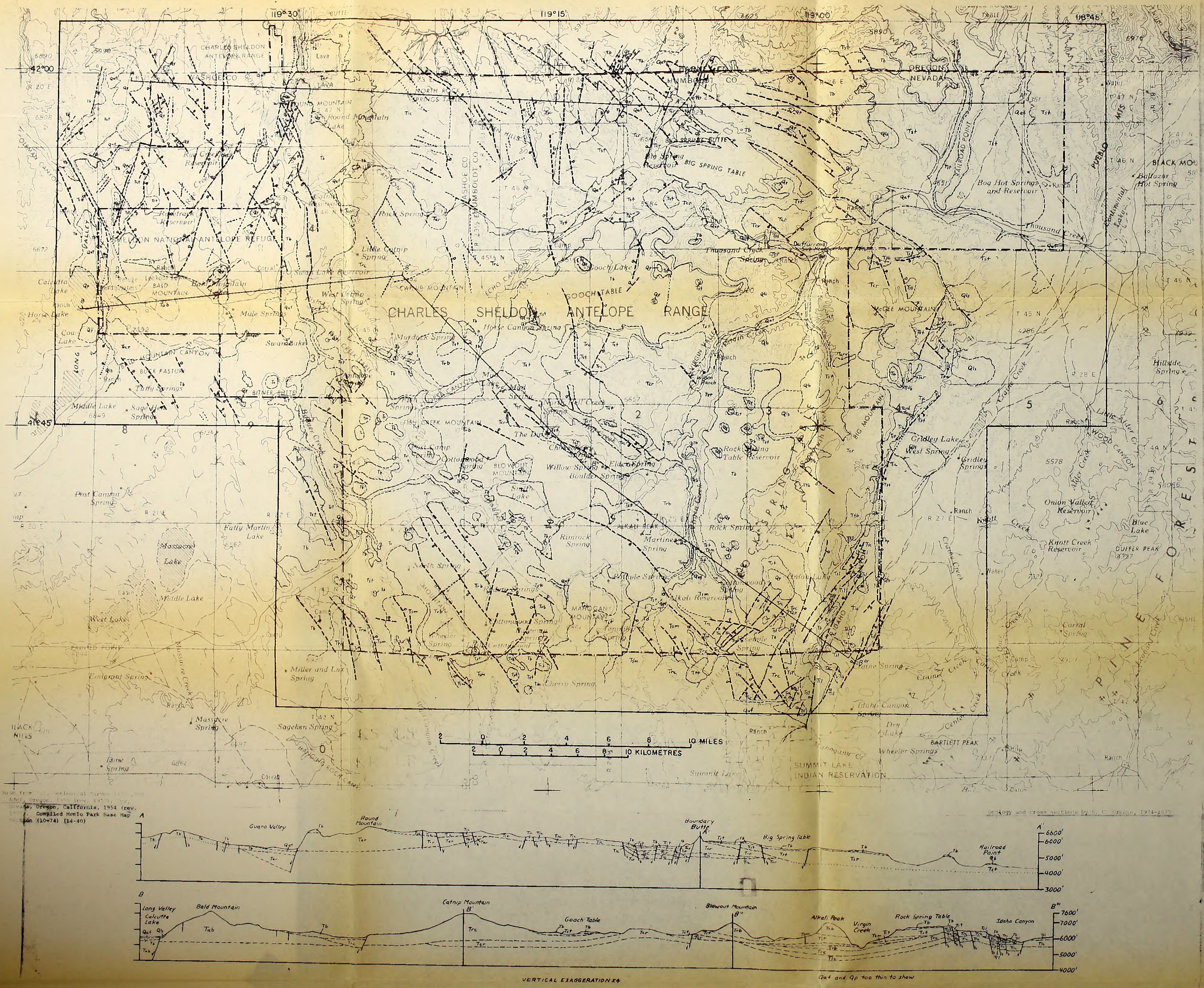
PLATE 1


119°30'
119°15'
119°00'
118°45'
42°00'
41°45'
CHARLES SHELDON ANTELOPE RANGE
OREGON
NEVADA
WASHOE CO
HUMBOLDT CO
Big Spring Table
Gooch Table
Catnip Mountain
Bald Mountain
McGee Mountain
Round Mountain
Thousand Creek
Virgin Valley
Summit Lake Indian Reservation
Bog Hot Springs and Reservoir
Railroad Point
Pueblo Mts
Idaho Canyon
Swan Lake
Guano Valley
Long Valley
Calcutta Lake
Mahogany Mountain
Rock Spring Table
Alkali Peak
Blowout Mountain
Big Mountain
Pine Forest
0 2 4 6 8 10 MILES
0 2 4 6 8 10 KILOMETRES
A
A'
Boundary Butte
Big Spring Table
Railroad Point
6600'
6000'
5000'
4000'
3000'
B
B'
B''
B'''
Long Valley
Calcutta Lake
Bald Mountain
Catnip Mountain
Gooch Table
Blowout Mountain
Alkali Peak
Virgin Creek
Rock Spring Table
Idaho Canyon
7600'
7000'
6000'
5000'
4000'
VERTICAL EXAGGERATION X4
Qaf and Qp too thin to show

Base from U.S. Geological Survey 1:250,000 Adel, Oregon, 1955 (rev. 1973); Vya, Nevada, Oregon, California, 1954 (rev. 1970). Compiled Menlo Park Base Map Section (10-74) (14-40)

Geology and cross sections by R. C. Greene, 1974-1975

E X P L A N A T I O N

Qaf	Qp	Qla

Pleistocene and Holocene — QUATERNARY

Surficial deposits
Qaf - Alluvium and alluvial fans
Qp - Playa deposits
Qla - Landslide deposits

Qb

Pleistocene

Basalt of Railroad Point

Tb	Tv	Tpt

Basalt and related rocks
Tb - Basalt of Catnip Creek
Tv - Mafic vent complexes
[redacted]
Tpt - Palagonite tuff
[redacted]

Trn

Rhyolite of Nut Mountain

Trb	Tsm

Rhyolite and Welded tuff
Trb - Rhyolite of Badger Mountain
Tsm - Soldier Meadow [redacted] Tuff

Ttt

Tuff of Trough Mountain

Trc

Rhyolite of Catnip Mountain

Tcr	Ttb	Tcrd	Tcrv

Miocene — TERTIARY

Rhyolite and Welded tuff
Tcr - Canyon Rhyolite
Ttb - Tuff of Big Mountain
Tcrd - Rhyolite dike
Tcrv - Rhyolite vitrophyre

Trw

Red welded tuff

Tsl

Summit Lake [redacted] Tuff

Tic

Idaho Canyon [redacted] Tuff

Tar	Tab	Td	Tbp

Andesite, Dacite, and Basalt
Tar - Andesite of Round Mountain
Tab - Andesite of Bald Mountain
Td - Dacite
Tbp - Porphyritic basalt

Trct

Rhyolite of Cottonwood Canyon

Tst — Tuffaceous sedimentary rocks
Recurs throughout the interval indicated

Contact

Fault
Bar and ball on downthrown side, dotted where concealed

Inferred fault

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PLATE 1.--GEOLOGIC MAP AND CROSS SECTIONS OF THE CHARLES SHELDON WILDERNESS STUDY AREA, HUMBOLDT AND WASHOE COUNTIES, NEVADA, AND LAKE AND HARNEY COUNTIES, OREGON

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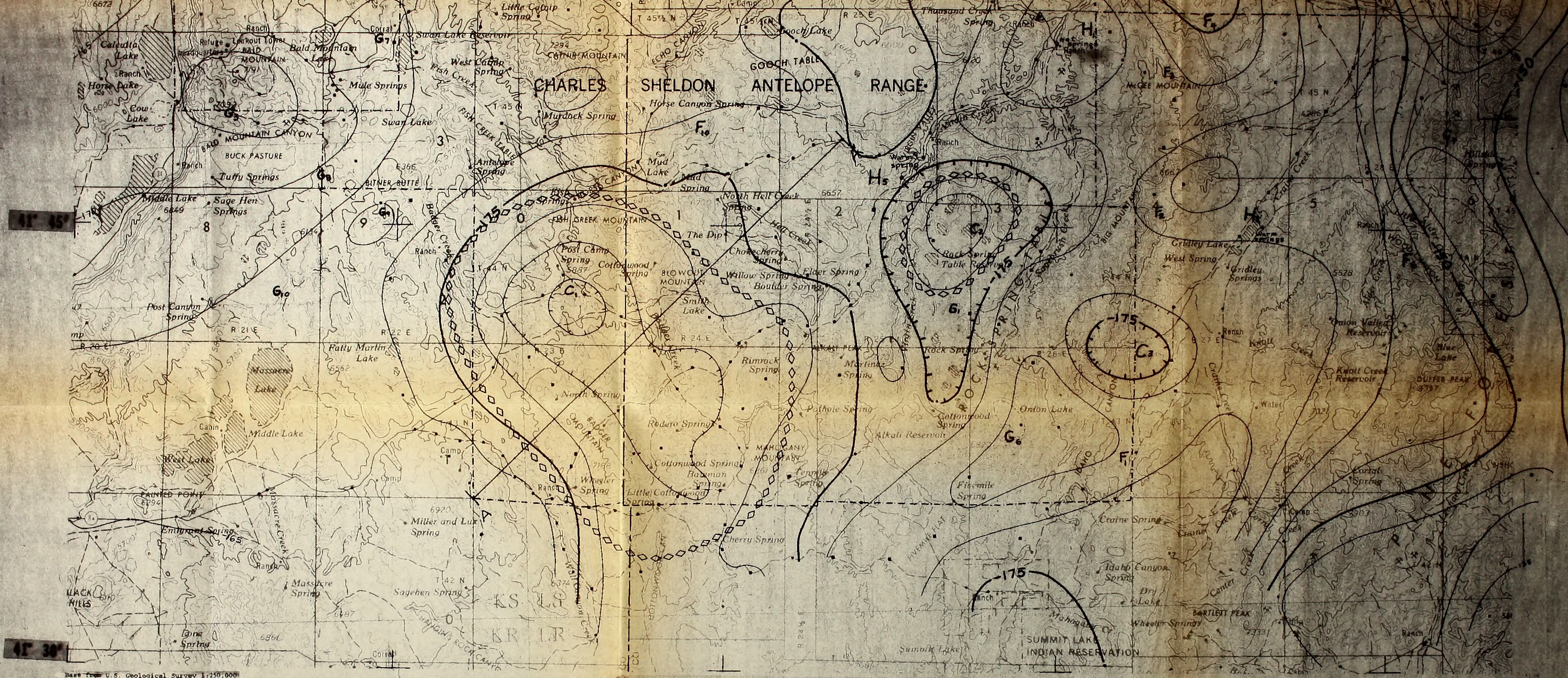
PLATE 3

119° 45'
119° 30'
119° 15'
119° 00'
118° 45'
42° 15'
42° 00'
HART MTN NATIONAL ANTELOPE REFUGE
Shirk Lake
Guano Lake
Horsehead Lake
Little Reservoir
Barry Reservoir
GUANO VALLEY
Spaulding Res
Dunes
LAKE COUNTY
HARNEY COUNTY
SAGEHEN BUTTE
ACKLY MTN
HAWK MTN
ANTELOPE BUTTE
CHARLES SHELDON ANTELOPE RANGE
BLACK ROCK TABLE
Lava
WASHOE COUNTY
HUMBOLDT COUNTY
OREGON
NEVADA
NORTH ROCK SPRINGS TABLE
ROUND MOUNTAIN
Round Mountain Lake
Rye Creek Reservoir
Catnip Creek
CATNIP CANYON
Catnip Reservoir
Rock Spring
Racetrack Reservoir
SHELDON NATIONAL ANTELOPE REFUGE
BIG SPRING BUTTE
Big Spring Reservoir
BIG SPRING TABLE
RAILROAD POINT
Bog Hot Springs and Reservoir
Thousand Creek
Thousand Creek Spring
Little Catnip Spring
Swan Lake Reservoir
CATNIP MOUNTAIN
West Catnip Spring
Fish Creek
Mule Springs
Swan Lake
Gooch Lake
GOOCH TABLE
Horse Canyon Spring
Murdock Spring
McGEE MOUNTAIN
Calcutta Lake
Bald Mountain Lake
BALD MOUNTAIN
Cow Lake
Horse Lake
BALD MOUNTAIN CANYON
BUCK PASTURE
Tuffy Springs
SITNER BUTTE
Antelope Spring
Mud Lake
Mud Spring
North Hell Creek Spring
Middle Lake
Sage Hen Springs
FISH CREEK MOUNTAIN
Post Camp Spring
Cottonwood Spring
BLOWOUT MOUNTAIN
The Dip
Chokecherry Spring
Willow Spring
Elder Spring
Boulder Spring
Smith Lake
Rock Spring Table
Gridley Lake
West Spring
Gridley Springs
Post Canyon Spring
Denio
-175
F₄
F₅
F₈
F₁₄
G₆
G₇
G₈
G₉
G₁₀
H₁
H₃
H₅
H₆



CHARLES SHELDON ANTELOPE RANGE
41° 45'
41° 30'
-175
-165
-150
C1
C2
C3
G1
G5
G6
G7
G8
G9
G10
H1
H2
H3
H5
F1
F2
F3
F10
Caleuita Lake
Bald Mountain Lake
Horse Lake
Cow Lake
Swan Lake Reservoir
Swan Lake
Mule Springs
Gooch Lake
Gooch Table
McGee Mountain
Murdock Spring
Horse Canyon Spring
Bald Mountain Canyon
Buck Pasture
Tuffy Springs
Bitner Butte
Middle Lake
Sage Hen Springs
Fish Creek Mountain
Post Camp Spring
Cottonwood Spring
Blowout Mountain
Smith Lake
The Dip
North Hell Creek Spring
Chokecherry Spring
Willow Spring
Boulder Spring
Elder Spring
Rock Spring Table Reservoir
Rock Spring
Big Mountain
Cridley Lake
West Spring
Gridley Springs
Onion Valley Reservoir
Knott Creek Reservoir
Duffer Peak
Blue Lake
Post Canyon Spring
Fatty Martin Lake
Massacre Lake
West Lake
Painted Point
Emigrant Spring
Massacre Spring
Sagehen Spring
Lone Spring
Black Hills
Miller and Lux Spring
Rodero Spring
Cottonwood Spring
Bauman Spring
Mahogany Mountain
Little Cottonwood Spring
Cherry Spring
Alkali Reservoir
Pothole Spring
Martinez Spring
Cottonwood Spring
Onion Lake
Fivemile Spring
Craine Spring
Idaho Canyon Spring
Dry Lake
Wheeler Springs
Bartlett Peak
Summit Lake
SUMMIT LAKE INDIAN RESERVATION
Corral Spring
R 20 E
R 21 E
R 22 E
R 23 E
R 24 E
R 26 E
R 27 E
T 45 N
T 44 N
T 42 N

Base from U.S. Geological Survey 1:250,000
Adel, Oregon, 1955 (rev. 1970); Vya,
Nevada, Oregon, California, 1954 (rev.
1970). Compiled Menlo Park Base Map
Section (10-74) (14-40)

SCALE 1:125 000

2 0 2 4 6 8 10 MILES

2 0 2 4 6 8 10 KILOMETERS

CONTOUR INTERVAL FEET
DATUM IS MEAN SEA LEVEL

Field data of 309 stations collected by [illegible] and [illegible], 1975; supplemented by data obtained from U.S. Dept. of Defense Gravity Library, [illegible], 1975. Compiled by Donald [illegible] 1976

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PLATE 3--COMPLETE BOUGUER GRAVITY ANOMALY MAP OF CHARLES SHELDON WILDERNESS STUDY AREA, HUMBOLDT AND WASHOE COUNTIES, NEVADA, AND LAKE AND HARNEY COUNTIES, OREGON

EXPLANATION

△
Gravity base station

Gravity station established in 1975 [illegible]

Gravity station in [illegible]

Gravity station established before 1975 [illegible] elevation determined by contour estimate

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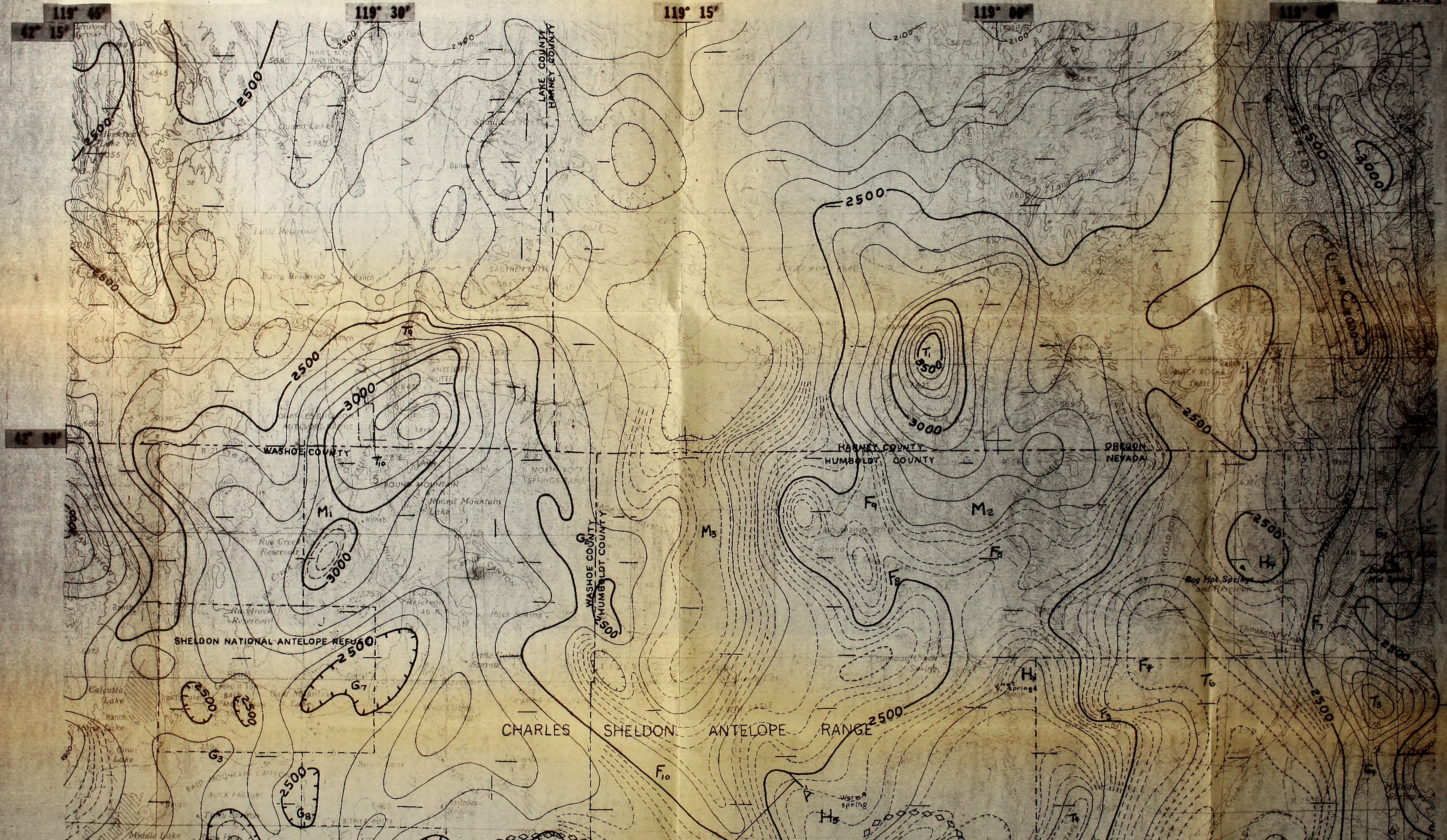
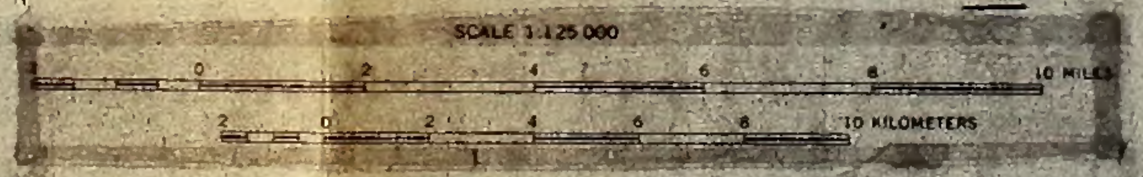
PLATE 2


119° 45'
119° 30'
119° 15'
119° 00'
42° 15'
42° 00'
LAKE COUNTY
HARNEY COUNTY
WASHOE COUNTY
HUMBOLDT COUNTY
OREGON
NEVADA
SHELDON NATIONAL ANTELOPE REFUGE
CHARLES SHELDON ANTELOPE RANGE
2500
3000
3500
2100
T₁
T₃
T₄
T₅
T₆
T₁₀
M₁
M₂
M₃
F₁
F₃
F₄
F₅
F₈
F₉
F₁₀
G₃
G₄
G₅
G₆
G₇
G₈
H₃
H₄
H₅
Bog Hot Springs and Reservoir
Warm spring

41° 45'
G3
G8
G9
G10
C1
C2
C3
F10
F2
F1
F6
H5
H3
G1
G6
G4
T4
T1
T5
2500
2600
2800
3000
Plate 4
A
Warm Spring
Middle Lake
Middle Lake
West Lake
PAINTED POINT
Emigrant Spring
Miller and Lux Spring
Sagehen Spring
Rimrock Spring
Onion Valley Reservoir
Blue Lake
DUFFER PEAK
Idaho Canyon Spring
BARTLETT PEAK
SUMMIT LAKE INDIAN RESERVATION
Lone Spring
BLACK HILLS
Corral
Ranch

Base from U.S. Geological Survey 1:250,000
Adel, Oregon, 1955 (rev. 1970); Vya,
Nevada, Oregon, California, 1954 (rev.
1970). Compiled Menlo Park Base Map
Section (10-74) (14-40)


SCALE 1:125 000
0
2
4
6
8
10 MILES
10 KILOMETERS

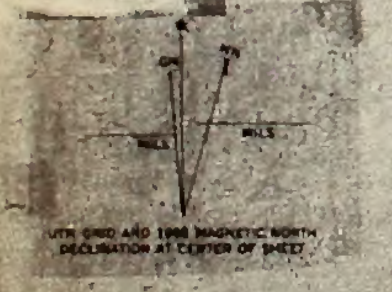

UTM GRID AND 1968 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

PLATE 2--AEROMAGNETIC MAP OF CHARLES SHELDON WILDERNESS STUDY AREA, HUMBOLDT AND WASHOE COUNTIES, NEVADA, AND LAKE AND HARNEY COUNTIES, OREGON

[illegible]

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Magnetic contours
Showing the total-intensity magnetic field of the earth relative to an arbitrary datum. [illegible] 20 gammas.

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PLATE 4

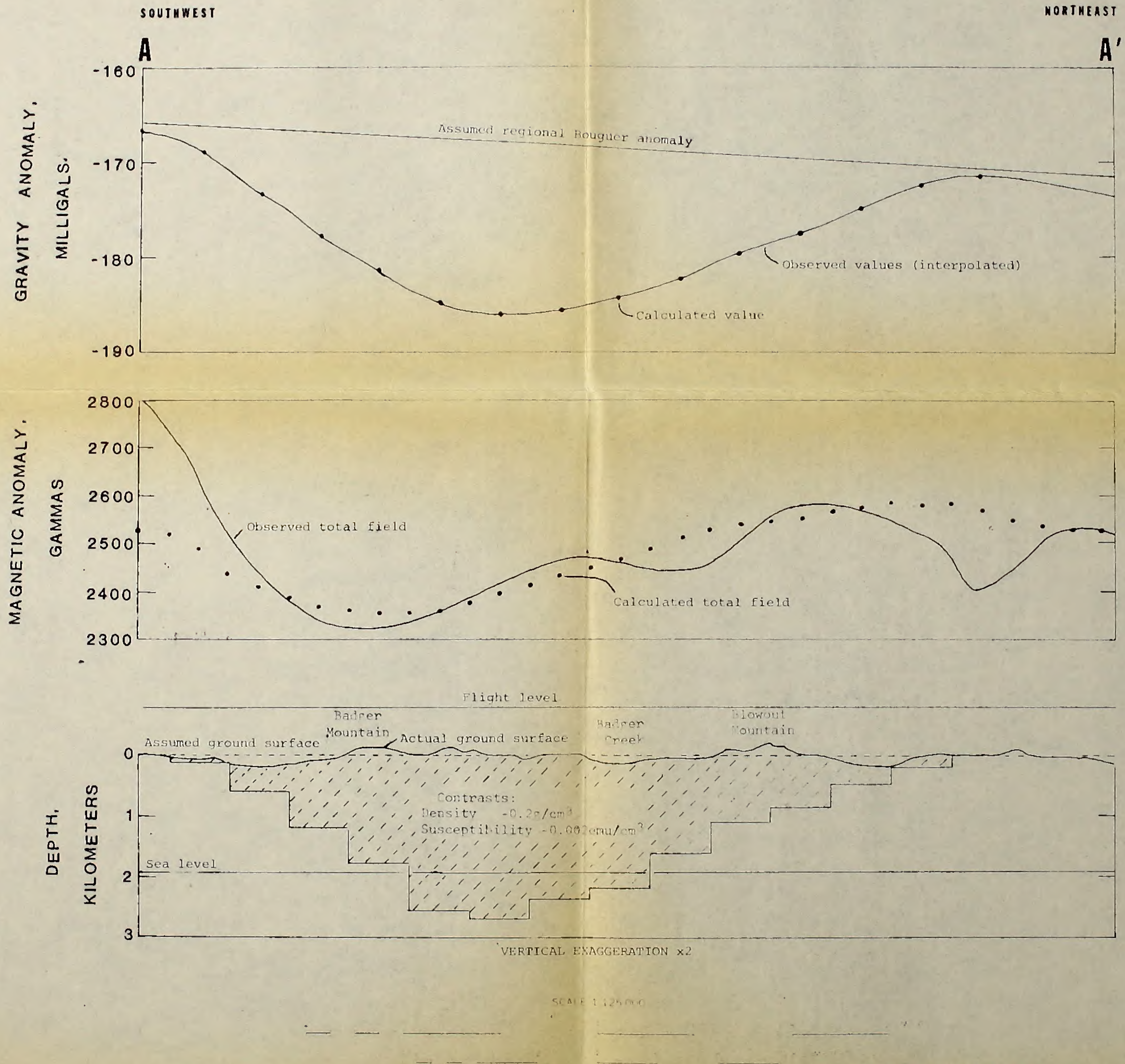

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PLATE 4--INTERPRETATION OF GRAVITY AND MAGNETIC ANOMALIES ALONG PROFILE A-A'

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s Card

rces of the Charles
derness study area,
d Washoe Counties,
Lake and Harney Counties,

r	Division	Date Ret'd
	D 440	SEP 15 '83

DSC 1279-3a (Feb. 1977)